Next Meeting, The American Association of Orthodontists, San Francisco, California, May 8 through 12, 1955. Headquarters, The Fairmont Hotel.

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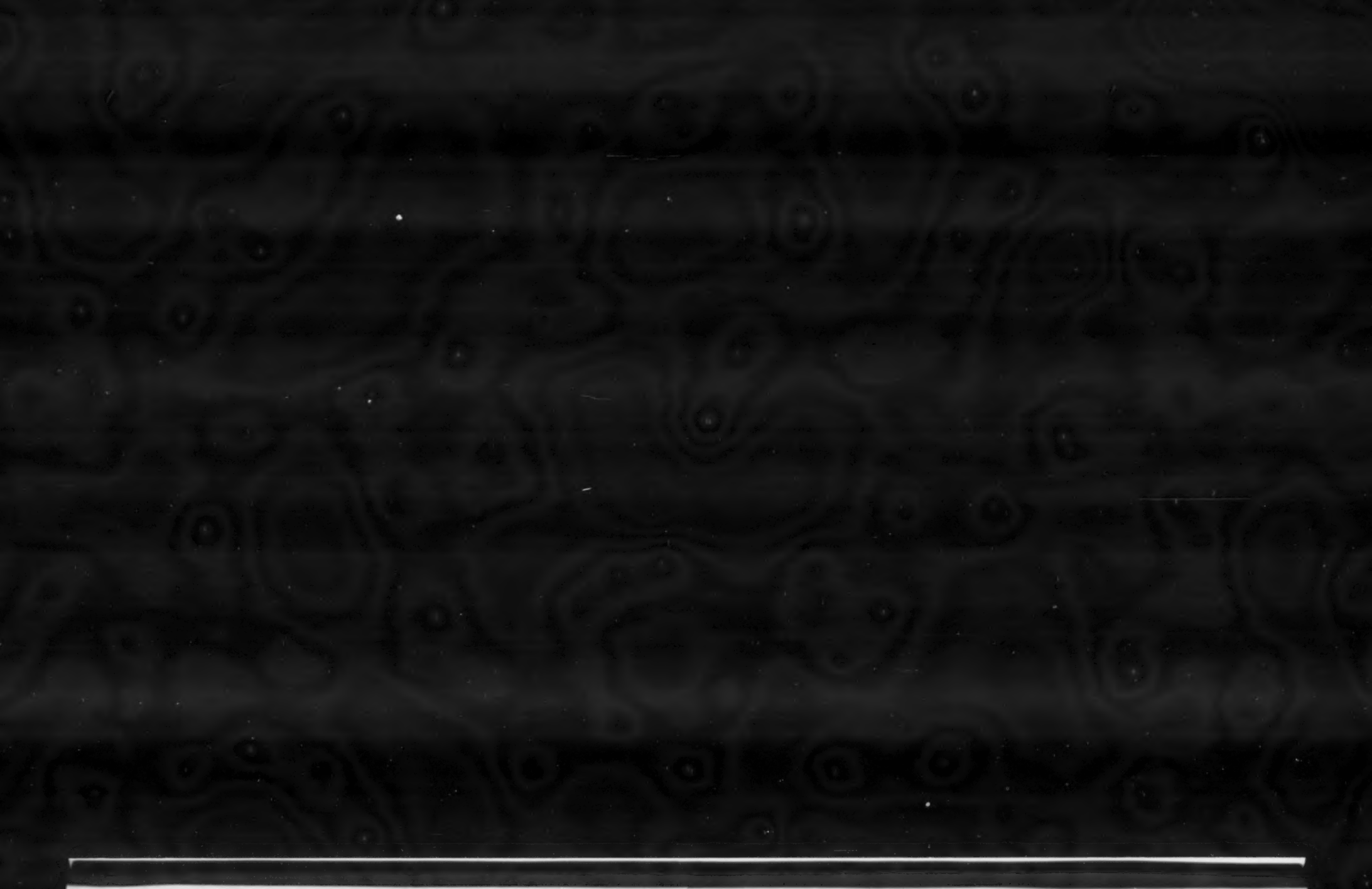

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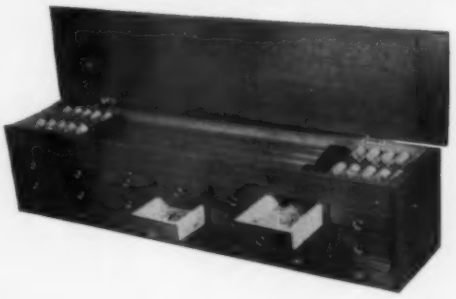

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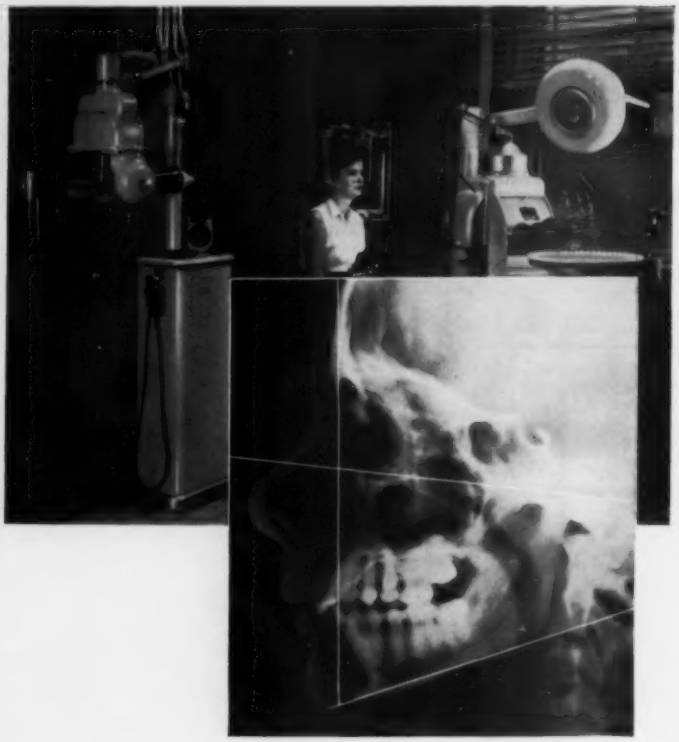

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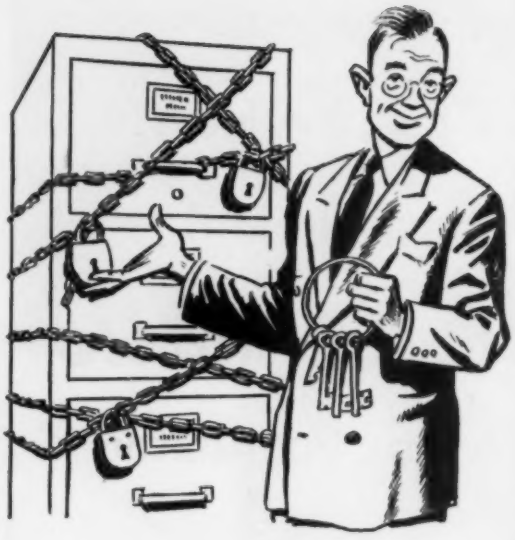

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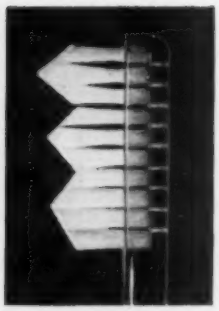

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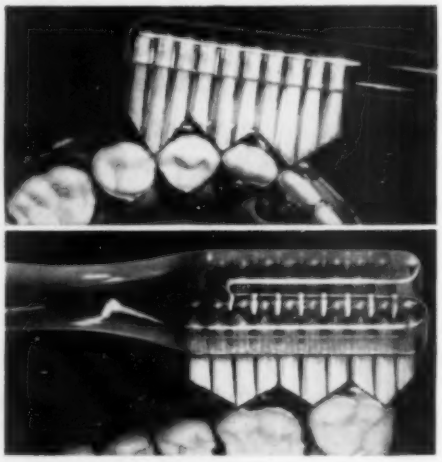

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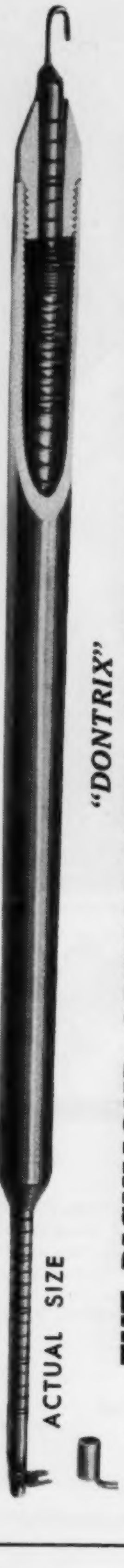

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American Journal

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VOL. 41 MARCH, 1955 NO. 3

Original Articles

PRESIDENT'S ADDRESS, CENTRAL SECTION OF THE AMERICAN ASSOCIATION OF ORTHODONTISTS

EARL E. SHEPARD, D.D.S., ST. LOUIS, MO.

AT THIS, the seventeenth annual session of the Central Section of the American Association of Orthodontists, it is my pleasure as your presiding officer to greet you and to welcome you to St. Louis, the birthplace of modern orthodontics, where in 1901 our parent organization, then known as the American Society of Orthodontists, first saw the light of day.

Just eight years ago, at Minneapolis, we held our first scientific session. Since that time we have held annual meetings which have been of great benefit to each of us, not only professionally, but from the standpoint of the improvement of human relationships as well. A respect for each other, I am sure, has been engendered by our smaller meetings, which becomes evident on a more universal scale at the annual meetings of the American Association of Orthodontists.

The presidential address of Scott T. Holmes, of the Great Lakes Society, published in the July, 1954, issue of the AMERICAN JOURNAL OF ORTHODONTICS, carries an impact that I am certain many of you have felt when reading it. His reference to a lack of consideration on the part of many of us toward a more acceptable technique of patient transferral and acceptance is extremely interesting and important. Dr. Holmes's approach to this difficult problem, I believe, is one of the better things to consider, along with diagnosis and clinical

Presented before the seventeenth annual session of the Central Section of the American Association of Orthodontists, St. Louis, Missouri, Oct. 4, 1954.

therapies in our field of endeavor. Ways and means for providing a routine for supplying information, either during a vacation period or at such time when permanent change of a patient's home becomes necessary, are certainly desirable. He suggests that a committee within his society be formed to study this problem. Certainly a feeling of mutual respect can be the only outcome of such a venture. It may well be considered by our own section.

Many important progressive changes have been wrought in our organization in the past eight years. We have grown tremendously from a membership of less than 100 to a large group numbering 183 active, 3 honorary, 2 retired, and 15 associate members. It is good to see that there are 8 applicants for active membership at this meeting and that we have 23 applicants for associate membership.

In 1951 President P. M. Dunn suggested that the membership be informed as to the proceedings of our annual meetings. This, and more, has been done through the publication of an annual *News Letter,* delivered to the membership. This is done near to the date of the annual meeting when all the pertinent data will be in the form of a reminder, fresh in the minds of the members.

Our official programs are becoming compendiums of reference not to be thrown away, but to be retained as important.

Is it not true, then, that we are offering more to members and do we not have infinitely more to present to our young aspirants?

One further service which we could render would be the addition of the block JOURNAL subscription price to the fee of the incoming associate members. They then would be able to take advantage of this special price and be certain to get the JOURNAL without delay.

Upon the able shoulders of one individual rests all of this work accomplished, and work yet to be done. This, of course, is our secretary, Fred Lehman, who has done and is doing a magnificent job. He is careful, efficient, farsighted, and, above all, possesses a keen sense of humor. I take this opportunity to thank him on behalf of the members, and particularly for myself.

In surveying our accommodations and the program of events, I shall always be personally grateful to Leo Lundergan, general arrangements chairman, and to our committees who have worked as only they know how.

To the officers and committeemen of the Central Section, I extend my heartfelt thanks for their every effort and, to the members, my gratitude for the opportunity of being your president. It is an honor which I shall always cherish.

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FACIAL AND DENTURE CHANGES DURING ORTHODONTIC TREATMENT AS ANALYZED FROM THE TEMPOROMANDIBULAR JOINT

ROBERT MURRAY RICKETTS, D.D.S., M.S., PACIFIC PALISADES, CALIF.

CHANGES in the face are better understood by an approach through the temporomandibular joint than by an analysis of the profile. Alteration of facial contour is merely the final expression of several contributing factors, among which mandibular condyle growth exerts the greatest influence. Therefore, the size and form of the bony framework of the oral cavity are determined, to a large degree, by growth behavior within the temporomandibular joint area.

Growth of the maxillary portion of the face is expressed mainly from the pterygoid buttresses at the tuberosity. Yet, the chin of the adult is more prominent than that of a child. Mandibular condyle growth not only keeps pace with the maxilla but it also provides the vertical dimension of the lower face and compensates for the backward movement of the glenoid fossa during the growth span.

The purpose of this article is (1) to describe the mechanism of growth of the mandible and its relation to changes in the face; (2) to show how identical treatment procedures will induce a variety of results in patients expressing different growth tendencies; and (3) to indicate how treatment should be geared to the manner of development of the face.

FINDINGS ON FORM AND FUNCTIONAL VARIATIONS

Studies of form and function of the temporomandibular joint have been conducted by employing cephalometric laminagraphy and have been reported previously.[10-14]

The form of the joint in a sample of 100 normal persons compared favorably with the same number of Class II cases (Fig. 1). Class III cases differed and were characterized by long and narrow condyles seated upward and forward in shallow fossae.

A comparison of the physiologic rest positions revealed that Class II conditions were associated with condyles in a downward and forward relationship in two-thirds of the cases (Fig. 1). No essential difference could be demonstrated in condyle position in fully occluded relationship of the teeth.

Presented before the Pacific Coast Society of Orthodontists San Francisco, California, February, 1953. (Based on papers read before the Charles H. Tweed Foundation for Orthodontic Research, Chicago, Illinois, April, 1952, and the Northeastern Society of Orthodontists, Montreal, Canada, November, 1952.)

The interocclusal dimension (freeway space) was found to be twice as great in Class II conditions and the path of closure was observed to be more distal than normal.

Correlations of denture behavior with function of the condyle substantiated the concept that abnormal rest positions of the entire mandible were typical of the Class II malocclusion. Surprisingly wide variations were observed in all aspects of the joint and denture. True, distal displacement of the condyle resulted from tooth interference, although much less than had been previously expected. Mesial displacements even in Class II cases were more common than anticipated.

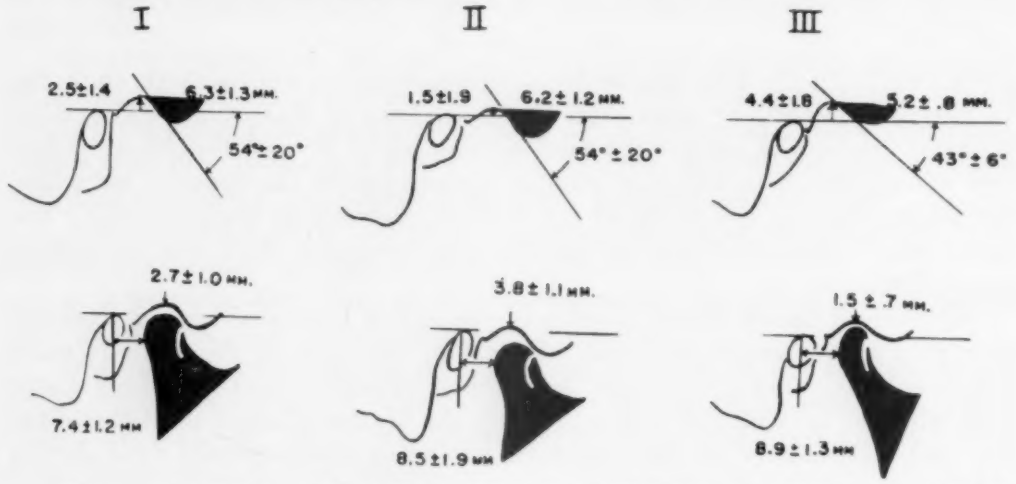

Fig. 1.—Variation in form of the eminence and differences in position of the fossa in normal persons and in patients with Class II and Class III malocclusions. Note the similarity in the angle and height of the eminence in Class I and Class II malocclusions. Note the form of the fossa, height, and angle of the eminence in Class III conditions.

Lower figures represent average condyle positions in the various groups. The figure on the left characterizes the normal by a well-centered condyle. The figure in the center represents the average condyle in Class II cases at physiologic rest. Note downward and forward position. Class III conditions are positioned upward and forward in the fossa. The numbers present means and standard deviations for the various measurements taken.

DISCUSSION OF FUNCTIONAL DIFFERENCES

The characteristic abnormal rest position was found in patients with a variety of facial form. The etiological factor, therefore, was thought to exist within the denture in most instances. Speculation is necessary in order to comprehend the possible effects of malocclusion upon the musculature.

The Class II malocclusion, namely, the deep overbite distal relationship of the lower arch and protrusion of the upper teeth, demands certain compensations of the musculature in order to function. For instance, greater mouth opening is needed to place food in the mouth and wide separation of the jaws is needed to manipulate the food. Because of maxillary protrusion, the mandible is brought forward four to five times the normal distance during the act of incision. Thus, the protruding component of the musculature is hyperfunctional, together with those muscles concerned with opening.

In speech activity in the Class II malocclusion, the protruding muscles again are needed excessively. The mandible is either moved forward or radi-

cal compensations are made by other parts of the oral apparatus if the sounds are to be made distinctly; examples are the sounds "s," "p," "b," and "m."

The two functional conditions, mastication and speech, appear to affect the physiologic rest position. However, in cleft palate cases no need for these compensations is present. Yet, the rest position still can be that of the typical Class II. These patients' behavior was at first a mystery until an examination of the pharynx revealed a large amount of tonsillar tissue. It was realized that the forward rest position possibly was a conditioned position in the interests of maintaining the airway. The mandible occupies a position in a chain of musculature including the tongue, hyoid bone, pharynx, and larynx. Functional conditions within these allied organs may alter the muscular pattern in deglutition and other functions.

In addition to the preceding influences, psychological states are important. Conditioned positions of the mandible such as the "Sunday bite" frequently account for Class II patients' reaching adulthood unrecognized by the dentist as Class II. Forward position for esthetic purposes, therefore, induces abnormal stabilizing action of the protruding component.

All these functional conditions initiate excessive activity of the opening and protruding units and relaxation of the retracting and closing components of the masticatory musculature. Therefore, attention is focused to the physiologic state of the external pterygoid muscle in the Class II malocclusion. Since this muscle is inaccessible and is difficult to study in the living, little is known of its condition under prolonged excessive function.

POSITIONAL CHANGES DURING TREATMENT

The same patients studied for Class II variation were studied after treatment in order to evaluate the changes occurring.

Changes in the position of the condyle were measured by superimposing the outlines of the fossa in the before and after tracings. A preponderance of posterior movement of the condyle was noted in the rest position.

Changes in the position of the condyle as determined by occluded relation of the teeth (occlusal condyle position) were great enough to warrant considerable attention. No appreciable change was noted in 60 per cent of the cases. However, as indicated in Fig. 2, 13 per cent were observed to move downward and forward in a range of 1 to 2 mm.; but, quite unexpectedly, the condyles in 27 per cent of the cases in the occluded relation of the teeth moved to a more distal position and became more seated in the fossa. Some of these moved nearly 3 mm. posteriorly and superiorly during treatment.

GROWTH OF THE CONDYLE

The growth of the condyle was measured along RR' line on the laminagraph tracings (Fig. 3). This line was drawn down the long axis of the neck of the condyle and picked by inspection. In a majority of cases this line intersected the lower border of the mandible near the antegonial notch. Therefore, the growth increments did not represent growth of the entire mandible but only growth from the inferior border of the mandible to the top of the condyle.

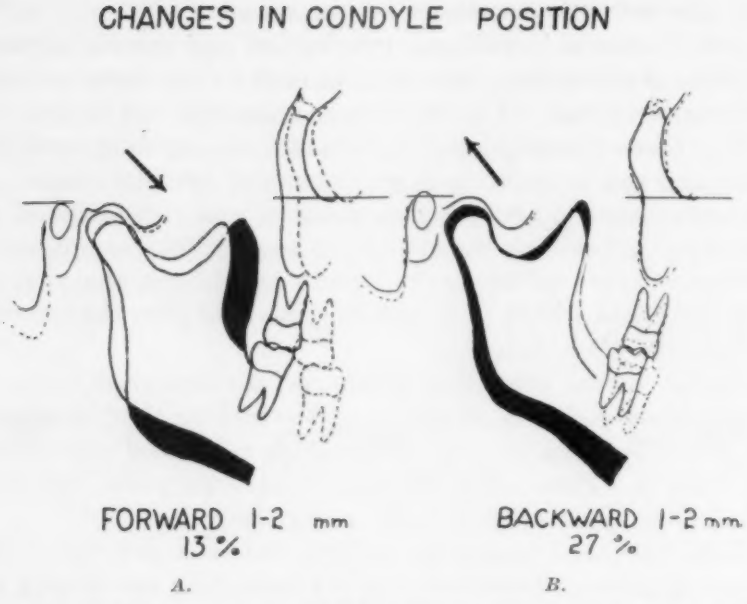

Fig. 2.—The possible changes in condyle position during treatment. *A* represents a case in which the mandible came forward during treatment an extreme of 2.5 mm. This was observed in relatively few instances and subsequent relapse was observed in some, but not all, of these conditions. *B* represents a rather common occurrence during treatment, in which the condyle was more seated and better centered after treatment than that observed before treatment. This phenomenon, observed in more than one-fourth of the cases, was a surprising observation.

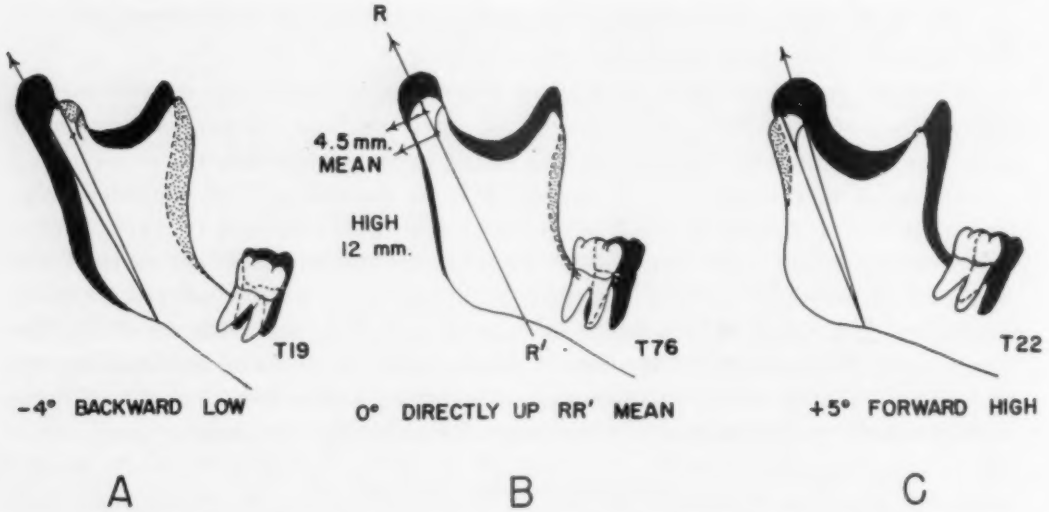

Fig. 3.—The growth of the condyle during treatment in amount and direction. The typical finding is demonstrated in *B*, in which the average condyle grew almost directly up the long axis of the neck of the condyle and in which the average case grew 4.5 mm. during the treatment period. *A* represents an extreme case of backward growth of the condyle, which is consistent with vertically growing faces and those increasing in mandibular plane angle. *C* represents a case in which the condyle grew upward and forward, which was consistent with chins swinging forward and mandibular planes decreasing.

Amount.—During treatment the average Class II case received 4.5 mm. of condylar growth, although the range was from 0 to 12 mm. Boys grew 3 mm. per year, while girls were observed to yield only 2 mm. per year in the sample studied. The average age for both boys and girls was 12 years at the start of treatment. The average time of treatment was twenty-five months, although cases were completed in a range from ten months to thirty-six months.

Direction.—Superpositioning of the mandibular borders and registering at the intersection of the *RR'* lines revealed the changes in direction of the growth of the condyle and the alteration of form of the mandible. Growth directly down the long axis of the neck of the condyle was the typical finding. However, 15 per cent were observed to grow upward and backward 2 to 4

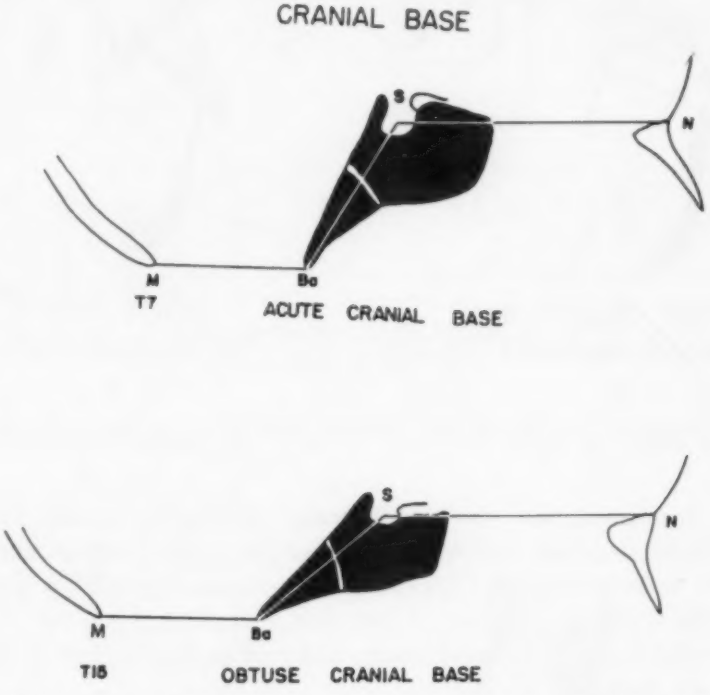

Fig. 4.—Variation in angular relation of base of occipital and sphenoid bone to nasion and the foramen magnum. The average falls midway between these extremes. Points *NSBa* form an angle of 120 degrees (above) to 140 degrees (below). This angle usually indicates a long or a short cranial base.

degrees and 22 per cent were noted to grow upward and forward 2 to 5 degrees. Therefore, more than one-third of Class II cases (based on these findings) can be expected to demonstrate growth patterns absent of parallelism of growth of the mandible. The concept of stability of the mandibular form is supported in only two-thirds of our sample.

REGIONAL FOSSAE CHANGES

The value of laminagraphy lies in its use as an adjunct to other methods. Since laminagraphy will not reveal areas outside its plane of focus, resort is

had to cephalometric headplates in order to expand the field of study. The changes in fossa position relative to other parts of the skull were therefore interpreted from the cephalometric films. Points *N*, *S*, and *Ba* were connected and the cranial base angle was studied for changes. This measurement resembles somewhat the "saddle angle" (NS-articular) described by Björk.[5]

Fig. 4 represents extremes of variation noted in the cranial base of the patients before treatment. The average angle was noted to be 130 degrees and the extremes were 121 and 141 degrees.

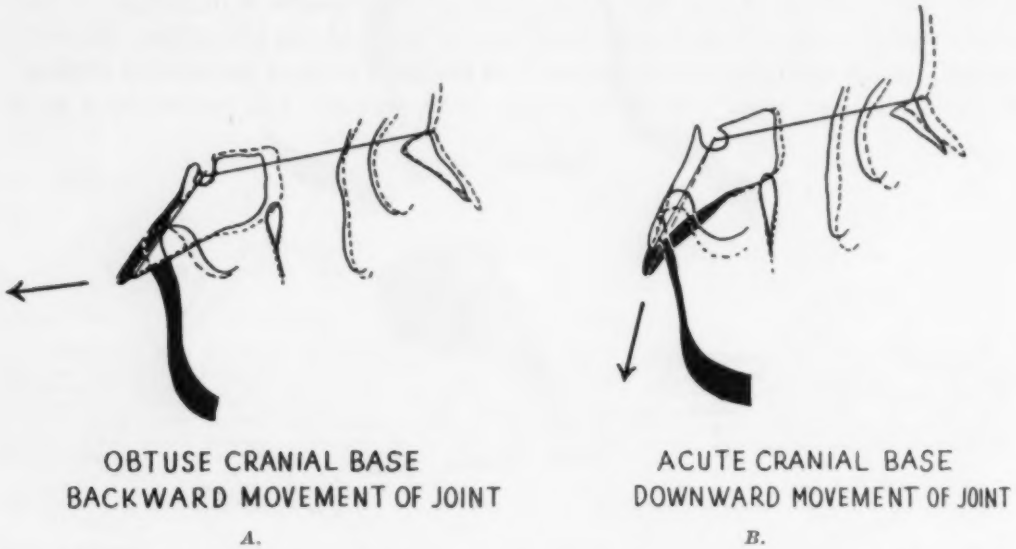

Fig. 5.—Changes in the cranial base during treatment. *A*, A case becoming more obtuse in cranial base angle; *B*, a case increasing vertically and becoming more acute in cranial base angle.

During treatment the average angular dimension (*BaSN*) showed no change, but individual cases were noted to become more acute or more obtuse by 2 degrees, as seen in Fig. 5. Linear measurements between points sella and basion revealed a change of about 1 mm. per year during the treatment period. No change could be seen in many cases, while some demonstrated slightly more than 1 mm. per year.

Other studies have suggested that after age 6 the glenoid fossa and the entire temporal bone behave similarly during growth.[3] Since basion and the glenoid fossa are both posterior to the spheno-occipital suture, changes in the cranial base are consistent to a degree with change in the position of the fossa. This needs further investigation, however. Changes in the regional relationship of the fossa as effected by changes in the cranium either offset or augment the effective growth of the mandible. Backward movement of the cranial base together with the glenoid fossa cancels out a portion of forward growth of the mandible, while direct vertical movement carries the mandible directly downward. Local modification of the fossa and the temporal bone were noted in some cases. Although in a minority, these changes affected the over-all growth resultant in the face when they occurred.

CHANGES IN THE FACE

In order to determine the effects of the joint changes on the face, the before and after headplates were traced and the findings of cephalometrics were correlated with those of laminagraphy. The angle formed by the intersection

Fig. 6.—Variations of facial patterns in Class II malocclusions as visualized from the crossing of the Y axis with the BaN plane. Note, in *A*, the high mandibular plane angle, low facial angle being correlated with the −7 degree Y axis to the BaN plane. *B* represents the average type of case observed in Class II. The +3 degrees indicates a slight tendency toward a retrognathic pattern. *C* represents the opposite extreme of *A*, revealing a +12 degree Y axis angle, a more than 90 degree facial angle, and a low mandibular plane. All are consistent with a short, square type of face. Even in such instances, the outward appearance of the face may appear retrognathic.

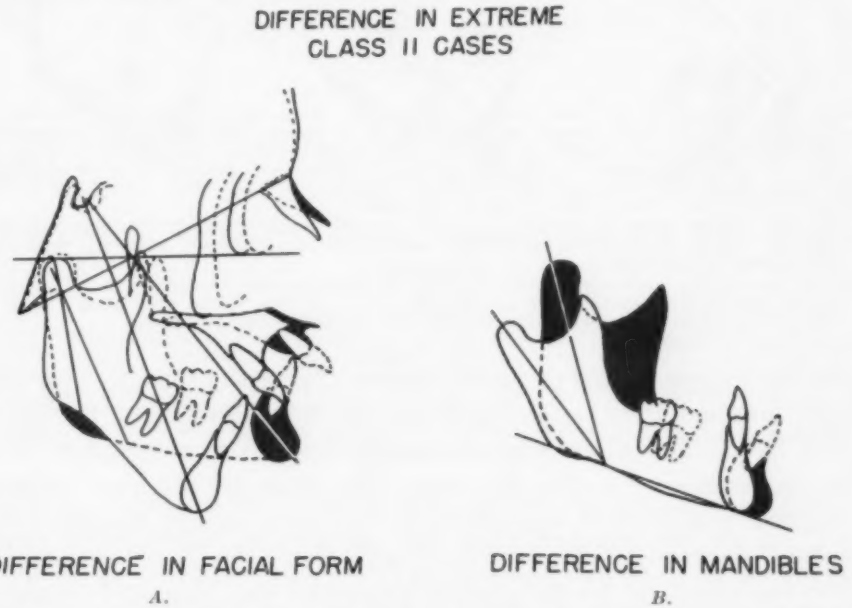

Fig. 7.—A composite of cases *A* and *C* in Fig. 6. Note the difference in height of the face and position of the chin in the two patients. Notice that the patient exhibiting a short and obtuse rampus is associated with a long and retrusive face. Note that long, high, acute rami are associated with shortness and deep overbite.

of the Y axis with the basion-nasion plane was studied because this measurement simplified the evaluation of changes in the chin position during treatment (Fig. 6).

This method, tested on normal cases,[8] revealed a low of plus 3 degrees and a high of plus 10 degrees. The variation in our Class II cases yielded a low of minus 7 degrees and a mean of plus 3 degrees, but a high of plus 12 degrees. Superpositioning of cases *A* and *C* in Fig. 6 reveals the cranial angles and dimensions to be similar. The significant differences were almost entirely limited to the form of the mandible (Fig. 7).

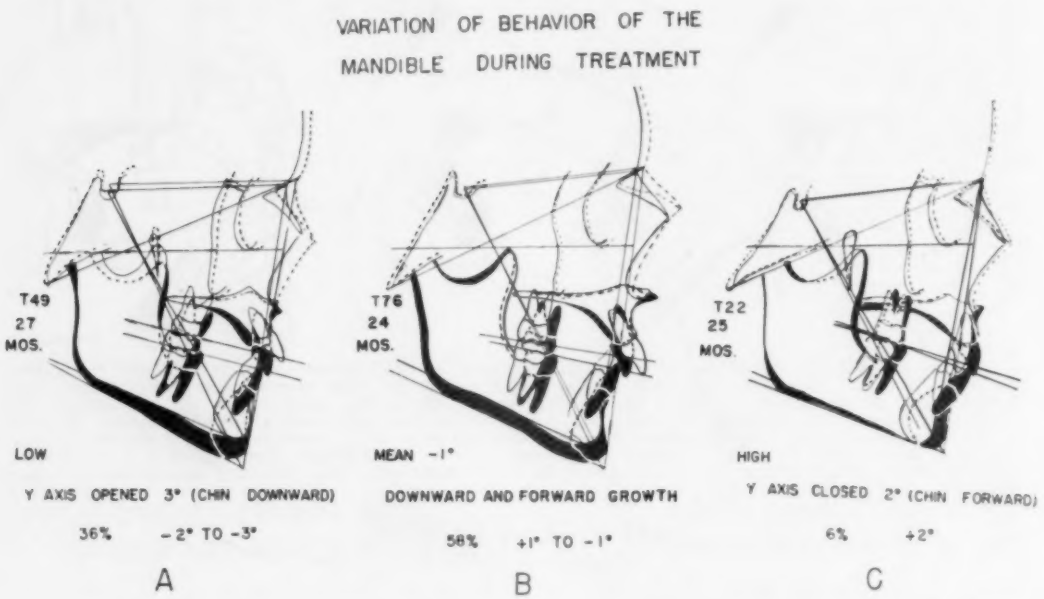

Fig. 8.—Changes in the face during treatment. Note the average (*B*) shows 1 degree opening of the Y axis with growth contributing to a downward and forward position of the chin. Almost 60 per cent varied no more than 1 degree from the original when superimposed on basion-nasion plane. Growth could contribute to excessive vertical development (*A*) in more than one-third of the Class II cases. Predominate horizontal growth was characteristic in 6 per cent of the Class II patients.

Behavior of the face is usually correlated with type of growth of the mandible, viz., obtuse gonial angles with vertical growth and acute mandibular patterns with horizontal facial development (see Fig. 3).

Faces developing vertically were observed to yield poorer anchorage than in cases showing horizontal behavior, especially if accompanied by rotation of the mandible. Depression of teeth was necessary in the correction of overbite in horizontal patterns.

The opening or closing of the Y axis was evaluated by means of superimposing the before and after basion-nasion planes and registering at the intersection of the Y axes. This plane was employed when it was observed to be a more critical measurement than the SN plane. The range for changes measured from basion-nasion plane was 5 degrees, while the same change measured from SN plane was 7 degrees. Thus, growth directly down the Y axis was evaluated 0, forward movement of the chin point designated was plus, and opening of the Y axis indicated minus values. The Y axis in the average Class II case was found to open almost 1 degree (Fig. 8). Cases opened (face lengthened) as much as 3 degrees or closed as much as 2 degrees.

Face lengthening on the Y axis was evaluated by superimposing the chin outlines and measuring the difference in the distance to the center of sella

turcica or point S. This method yielded an average Y axis increase of 6 mm. during treatment. One case was observed not to change, while another showed additions of 16 mm. on the Y axis.

CHANGES IN THE TEETH

The occlusal plane of the headplate was selected as a line joining the first molar occlusion and the bisection of the incisor overbite. The mandibular planes and chin points were superimposed in order to determine the changes in the occlusal plane from the mandibular plane. A tipping of the occlusal plane up in back or down in front was thus indicated by plus values. Zero values indicated no change, while minus values indicated a rise of the plane in the anterior end. The findings revealed the range of behavior to be plus 7 to minus 5 degrees change. The average occlusal plane during treatment increased 3 degrees. All minus values witnessed greater eruption of the lower incisors during treatment than could be detected at the lower molars and all were headgear or cervical anchorage cases. The eruption of the lower first molar was found to average 3 mm., with the range varying from 0 to 7 mm.

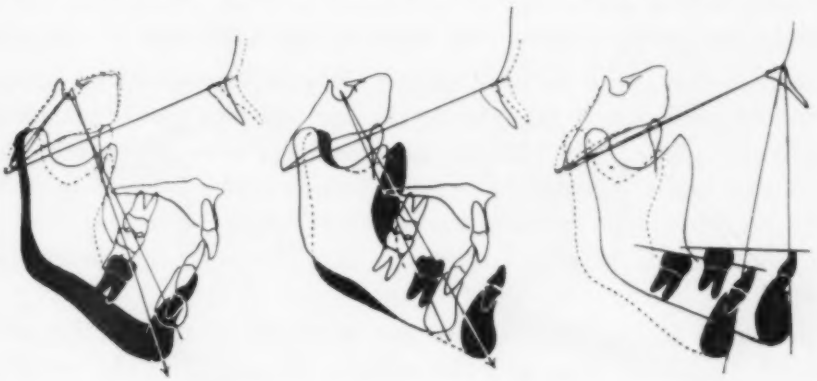

Fig. 9.—Possible facial changes in the individual case. If all factors contributing to a vertical development were found simultaneously the face would behave as in *A*. These factors are: opening of the cranial base, distal growth of the mandible, and distal positioning of the condyle in the fossa. These exclude bite opening. Rotation of the mandible added to these factors would show much greater vertical change.

B represents a forward growth pattern of the condyle in addition to mesial positioning within the fossa. Differences in possibilities are brought out in *C*.

A measurement of the changes in length of the mandibular plane from antegonial notch to the symphysis was made to complete the study of the entire mandible during treatment. The findings indicate that an average of almost 1 mm. per year can be expected along the mandibular plane. Cases were noted to increase as much as 2 mm. per year and these could be correlated with the type of growth pattern.

CORRELATION OF LAMINAGRAPHIC AND CEPHALOMETRIC STUDIES

Condyle Positioning.—Three of the six cases showing forward positions of the chin (closing of the axis) were correlated with forward positioning of the

condyles on one or both sides. Three of the nine extreme cases of chins dropping downward revealed posterior positioning of the condyles, usually bilaterally.

Growth Change.—Forward growth of the condyle was observed in the remaining cases experiencing chins moving forward of their original position. One-half the cases exhibiting lengthening of the face were correlated with predominate backward growth of the condyle. Thus, forward growth of the condyle was correlated with forward swing of the face, and backward growth of the condyle contributed to lengthening of the face at the chin.

Regional Fossa Changes.—Not all cases, however, were explainable on the growth pattern of the mandible or by condyle repositioning but, as mentioned previously, changes in position of the fossa were important. Posterior positioning of the fossa contributed to the chin growing forward, while a dropping of the fossa was consistent with greater height increase. In Fig. 9 the effects of each possibility are added together to show the total theoretic possibilities of behavior during treatment. These total possibilities, although extensive, are not fantastic, because individual cases have approached them.

CORRELATION OF BEHAVIOR OF THE DENTURE WITH CHANGES IN THE JOINT

No correlation could be seen in the changes in amount or direction of growth of the condyle and behavior of the occlusal plane when measured from the mandibular plane. The changes in some cases were accountable by eruption of molars, while others were greatly influenced by depression of incisors. Since the methods of treatment varied (extraction, nonextraction, cervical traction, and varying length of intermaxillary elastics), this naturally would be expected.

There seems to be rather significant correlation between the amount of eruption of the lower molar and the amount of growth of the condyle. The lower molar erupted more than condylar growth in only three cases. However, even in these cases the downward traveling of the fossa accounted for the difference. Eruption of the lower molar followed growth of the condyle within 4 mm. in all but four cases. These latter cases demonstrated greater eruption of the maxillary teeth. Unless the growth pattern is bizarre or the glenoid fossa migrates, the lower molar, therefore, usually can be correlated with growth of the condyle during treatment.

Positioning of the condyle often affected the time necessary to attain Class II correction of the condyle. In many cases headgear was worn for several months, or elastics were employed, without the usual progress in arch correction. Close examination revealed that these cases were improving, but that the condyle position was merely being corrected from a downward and forward position at the start of treatment. Continued traction finally resulted in arch correction only after the condyle had been seated in the fossa.

In other instances the condyle was well seated in the fossa at the start of treatment. Initial elastics and only slight correction brought about conditions favoring inclined plane action of the teeth and forced the mandible for-

ward. An apparent spontaneous correction resulted. However, in such instances continued traction was needed to correct the condyle position.

THE MECHANISM OF GROWTH OF THE MANDIBLE AND CHANGES IN FACES

The changes in condylar rest position during treatment are consistent with those of Boman.[1] Boman and Thompson, however, held to the theory of constant rest position on the basis that upward and backward growth of the condyle occurred as the chin position remained the same. Such ideas are tenable under the hypothesis that the original forward rest position results from discrepancies in the skeletal pattern in which the drape and elasticity of the muscles hold the mandible forward. However, changes in condyle position were observed without growth. This finding directs attention to changes in musculature.

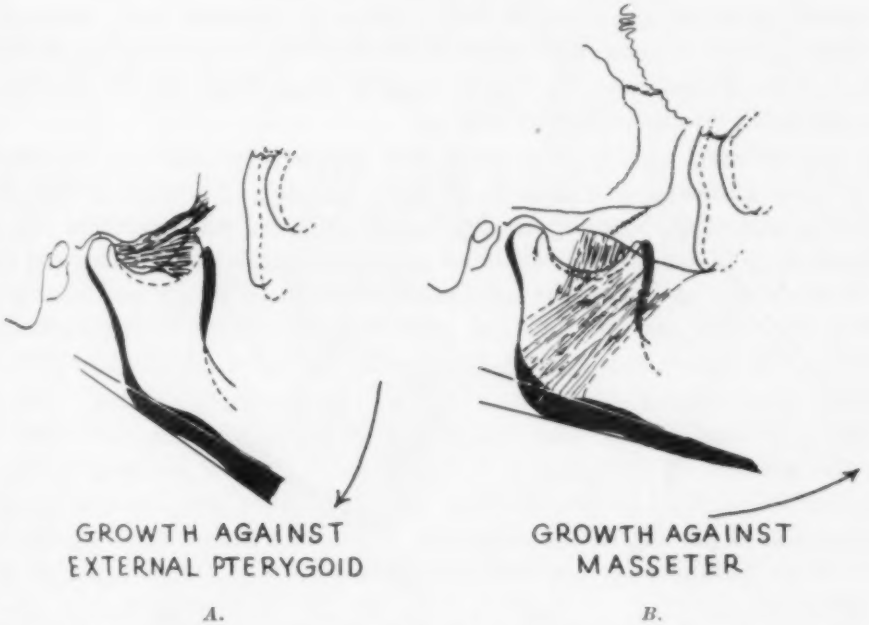

Fig. 10.—The mandible grows together with musculature. Distal growth of the condyle contributes to lengthening of the face due to the fact that the condyle is held forward against the eminence by the external pterygoid muscle (*A*). Upward and forward growth of the condyle contributes to forward swing of the chin as the ramus is pushed downward and backward against the pull of the masseter and temporal muscles (*B*).

Alizarinization and histologic studies have indicated that after the age of approximately 6 years the mandible grows mostly at the condyle, the posterior border of the ramus, the sigmoid notch, and the alveolar process. Cases with arrest of growth of the condyle have suggested that condylar growth influences development of almost the entire mandible and even the temporal bone.[9, 14] The upward and backward growth of the condyle, therefore, is held to account for the downward and forward descent of the chin. This is the typical pattern of growth in which the mandibular plane remains almost constant to certain cranial planes.

As stated previously, however, one-third of our sample behaved dissimilar to the typically described case. Chins either swing forward or swing back, depending for the most part on the type of growth of the mandible.

These influences are understood when it is realized that the mandible grows together with pull of musculature and not directly against the fixed base of the glenoid fossa. It is my contention that the changes in rest position are due primarily to alteration in the neuromuscular system. It is my further belief that the normal condyle in occlusion is well seated and well centered in the glenoid fossa and that this position represents the most constant position when all related structures are in harmony and balance.

The examples in Fig. 10 will serve to clarify these points. It will be noted in the figure on the left that posterior growth of the condyle contributes to a downward thrust to the chin. This observation, incidentally, contradicts the idea that forward pulling on the mandible by elastics contributes to backward development of the condyle and results in forward movement of the chin. This growth phenomenon is due to the fact that the condyle is stabilized in contact with the eminence by the external pterygoid muscle, while the angle of the mandible remains relatively stable.

It will be seen also that upward and forward growth of the condyle, which at first glance would seem to direct a downward and backward movement of the mandible, actually contributes to forward movement of the chin. This apparently is caused by resistance to the downward and backward movement of the angle of the ramus by musculature, namely, the masseter group. The chin, therefore, rotates upward and forward. Björk[4] observed similar behavior in cases developing prognathism but offered a different explanation.

These observations direct attention to the pterygoid plates. We have seen from previous studies[2] that the pterygoid plates serve as buttresses from which the growth of the maxilla is expressed. It now seems possible that these same plates, through the function of musculature, are also the buttresses for expression of growth of the mandible. Thus, the entire facial development is dependent, perhaps, on the basal support of the pterygoid plates of the sphenoid bone.

GROWTH AND ITS RELATION TO TREATMENT

The question is asked, "How does a knowledge of growth help me to treat a case? I still have to move the teeth." In order to take advantage of growth we must have some idea, first, of its amount and, second, of its direction. We should think in terms of growth on the Y axis and plus or minus changes in the Y axis in evaluating facial change.

Cephalometric headplates and laminagraphs indicate that in most Class II cases, correction of molar relationship is accomplished essentially by growth of the mandible, tipping of the occlusal plane, and forward movement of the lower arch (Fig. 11). The upper molars are usually moved backward, held in position, or caused to move directly downward, while the mandible carries the lower arch downward and forward. A knowledge of the amount of growth

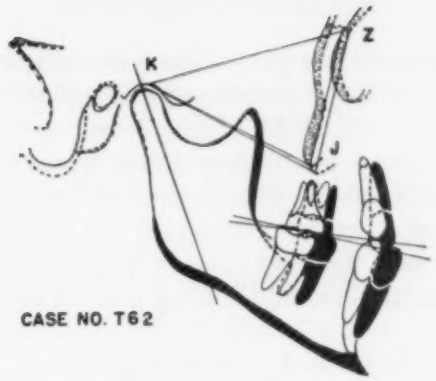

Fig. 11.—Behavior in the average case in Class II correction as viewed from laminagraph section with the fossa registered and oriented on zygomatico-frontal sutures. Note that the lower cuspid and molar are carried downward and forward in relation to the joint. In the final analysis the upper cuspid is tipped backward and the upper molar travels downward and forward at a slower rate than the lower. Note that the average angle, *K* (fossa) *Z* (zygomatico frontal suture) *J* (jugal process), did not change during treatment.

GROWTH AND TREATMENT CHANGES

DURING CERVICAL TRACTION

Fig. 12.—A case picked to illustrate the effects of growth, cervical traction, and bite plate during treatment. Notice the total changes in upper left as visualized by superposing on basion-nasion and registering at the Y axis. The upper arch appears to be moved back totally as good mandibular development occurred. The upper molar was held upright (even tipped mesially) as distal movement was accomplished. An upward and forward growth of the mandible occurred as some mesial drift of the lower arch appeared. Drift possibly was due to effect of the bite plate. Treatment time was only sixteen months in a boy aged 8 years.

of the mandible will indicate the probable position of the chin and give a clue to the expected position of lower incisors after elastics have been worn or after headgear has been utilized (Fig. 12).

The direction of growth is also important to success in treatment. Adequate prediction of growth will indicate, for instance, whether overbite will be corrected by downward growth, rotation of the mandible, or by depression of teeth. Needless to say, wedging the teeth into their sockets is more difficult than holding them in place and letting growth account for the improved incisor relationship.

Probably the most important aspect of growth is its relationship to anchorage in the lower arch. Patients with high mandibular plane angles and open Y axes were found to exhibit vertically growing faces, even though no changes were evident on the Y axis. Such growing faces afforded poor anchorage in the lower arch, due to the susceptibility of the lower arch to be jerked superiorly by elastics in the absence of powerful closing musculature. This observation corroborates Tweed's[15] contention on the poor prognosis in the patient with the high mandible plane angle and is probably one of the reasons for the present emphasis on preparation of anchorage in this type of case.

On the other hand, growth in a horizontal direction does not permit the bite to open and the forces of occlusion will prevent the lower arch from tipping at the expense of vertical development of molars. However, other problems are involved, chiefly the fact that the upper molars must be depressed if distal movement is to be gained (Fig. 9). Most cases of this kind are usually corrected almost entirely by a change due to growth, with mere depression of teeth being accomplished by mechanical therapy.

Having a knowledge of the eventual form and size of the face will indicate, therefore, whether or not the necessary tooth movement is possible. Knowledge of growth will frequently help to determine if teeth should be removed as a compromise in treatment. In addition, it will help decide on the teeth to be removed and the stage of treatment at which they should be removed. Knowledge of growth will also lend advice upon the borderline cases of crowded third molars following treatment. Finally, a knowledge of growth and tooth movement changes during treatment will help the clinician to arrive at a safe and practical retention plan, thereby effectively reducing posttreatment problems.

SUMMARY

Some of the most recent trends of thought on the biology and mechanics of orthodontic therapy have been presented. The importance of the knowledge of behavior of the temporomandibular joint has been stressed, beginning with variation and differences in malocclusion and continuing to its range of change during treatment. Attempts were made to show that within the temporomandibular complex lies the key to knowledge of growth and physiologic changes in the face during treatment.

The findings described herein suggest certain restrictions on the application of the mandibular rest position concept. Rest position changes during

treatment because it is abnormal at the start of treatment in Class II cases. In order to understand these changes, attention is directed to muscular accommodations in mastication, speech, deglutition, and respiration. Further research is suggested in the growth of musculature and its relation to growth of the face and the neurophysical adjustments necessary during these concomitant growth changes.

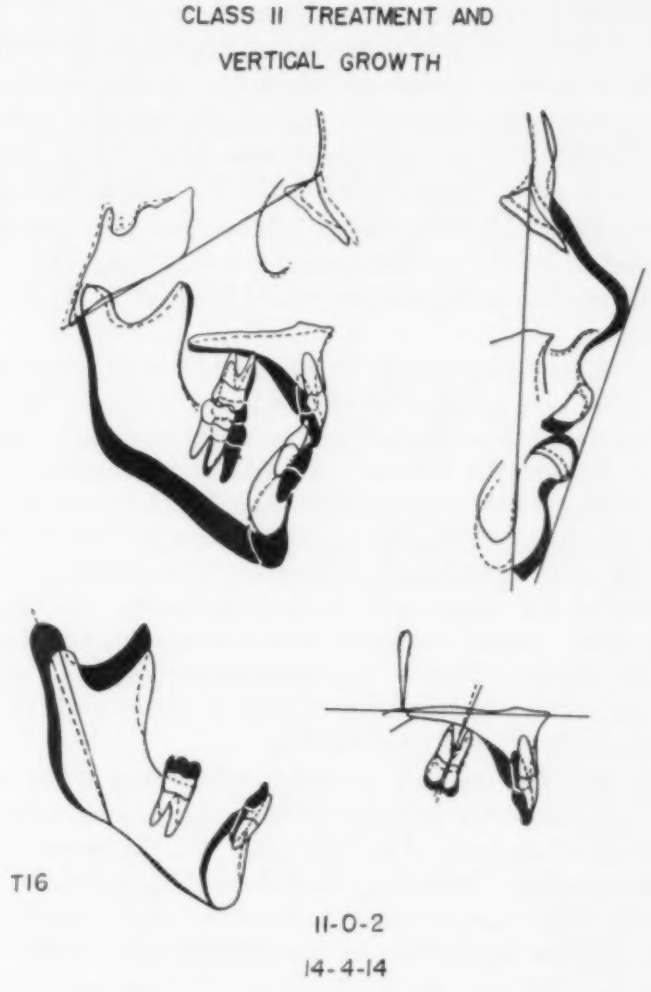

Fig. 13.—A case selected to illustrate the possible advantage of growth, even if predominantly in a vertical direction. Notice growth pattern of the mandible and distal position of the denture during the treatment and observation period. The patient, who had a Class III malocclusion was treated with intermaxillary elastics and a fully banded technique, and in spite of this the lower denture appeared more distal in the end than at the beginning. Changes in the upper arch and the soft tissue are evident in the figures on the right.

Changes in condyle position often explained spontaneous correction of Class II malocclusions. Adjustments of the condyle posteriorly also were found to be responsible for delayed arch correction in the presence of continued elastics or cervical traction. Changes in the condyle fossa relationship, therefore, were vitally important during treatment, but only intermittently effected the over-all growth pattern.

The observed changes in the face during treatment are the same as those described by Downs[7] and Donovan.[6] An evaluation of the joint offers certain possibilities of explanation for this behavior. Facial changes appeared to be influenced by the amount of condyle growth and by its direction of growth. Changes in the cranial base appeared to produce regional changes of the fossa and caused significant effects on the behavior of the face. Local alterations of the fossa were found to be important to a lesser degree.

Condyle growth usually was expressed up the long axis of the neck of the condyle, but the direction varied considerably. A correlation of headplate and joint roentgenographic findings revealed that condyle growth in a backward direction contributed to vertical increase in the face. A more vertical direction of condyle growth actually produced forward movement of the chin.

These changes are understood when it is realized that mandibular growth effects are dependent on the stabilization of musculature. Through this action of musculature, the chin is dropped or pulled forward in the variety of growing faces.

Facial growth was found to be important to anchorage of the teeth, correction of overbite, and positioning of the lower incisors. Movement of the lower molar correlated with growth of the condyle. Anchorage values thus were related to the growth pattern. Treatment of overbite in patients not expressing vertical growth was accomplished by the depression of incisors. A normal forward swing of the face carried the lower incisors forward as correct relationships were established. Intermaxillary elastics accomplished only a holding action of the upper arch in such instances. Gentle elastic forces were thus indicated. Rapid treatment was contraindicated when growth was employed for advantage. Growth was demonstrated to be of advantage, even to the extent of providing distal positioning of lower arch in spite of Class II elastics in expressing liberal growth (Fig. 13).

It appears that the method of laminagraphy has filled that important blind spot of cephalometrics and therefore serves as a valuable adjunct to it and other methods of analysis of malocclusion. At the present time the costly equipment is impractical. However, the information derived from the studies of laminagraphy, when applied to cephalometrics, will provide a clear understanding and a precise application of the cephalometric head films to clinical problems.

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OFFICE MANAGEMENT OF THE ORTHODONTIC PRACTICE

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ORTHODONTIC practice engaged in as a means of securing a livelihood becomes a business enterprise. The professional and business aspects are so closely integrated that it is difficult to draw a distinct line of demarcation to indicate which is professional and which is business. Models, x-ray pictures, histories, etc., ordinarily are thought of as purely professional, but failure to have adequate records of this nature could place the orthodontist in such a vulnerable position in a malpractice suit that it would result in economic disaster. In a like manner, failure to provide a proper recall system in regard to observation cases, ordinarily considered a business aspect, could result in failure to meet our professional obligation to the patient.

There have been numerous excellent articles published dealing with various aspects of office management of the orthodontic practice.

Gibben[1] in 1936, discussing "Efficient Practice Management," particularly as it relates to extending the availability of orthodontic service, stated, "If orthodontic practice is to fulfill its responsibilities in full measure, then it must grow and develop from a limited one man set-up to a highly efficient, carefully coordinated unit capable of producing not only the highest quality of service, but an increased availability of service in its respective community."

As a means of realizing these objectives he suggests:

1. The development of greater executive ability on our own part.
2. The development of a highly efficient organization of capable, well-trained assistants.
3. A more efficient and systematic management of our practices.
4. Increased facilities for efficient production.
5. Greater simplification of treatment along lines of the modern biologic concept.
6. Extensive educational publicity among both the dental profession and the laity regarding the beneficial results which may be accomplished through the interception and prevention of malocclusion.

In the discussion of the value of well-trained assistants, he enumerates the qualifications that must be possessed by the secretary, the laboratory technician, and the chair assistant.

He stresses the fact that efficient supervision and management of our practices are possible only when we are in possession of detailed information

Presented before the Northeastern Society of Orthodontists in New York, N. Y., March, 1954.

regarding all phases of our work. He presents in great detail his own system of records both professional and business.

Although this article was written nearly twenty years ago, it is well worth review, as it is basically sound and contains many valuable suggestions.

Koch,[2] in discussing "The Management of an Orthodontic Office," outlines three objectives:

1. To render a maximum of service with a minimum of effort.
2. To provide sufficient leisure during the working day to ponder over the inherent problems of an orthodontic practice, and to contemplate possible avenues of improvement in our professional techniques.
3. To provide sufficient net monetary income to afford us the opportunity of postgraduate study, and to provide a standard of living for our families commensurate with our ideals, desires, and our station in life, not only for the present, but also for those years when we will brag about what men we used to be.

In a rather semihumorous, philosophic way he discourses upon the necessity of having a clear-cut idea of what we want to do and how we want to do it; the dangers of procrastination; the desirability of concentrating on our practices and not diluting our energy by engaging in a lot of nonprofessional activities; the value of interludes of leisure for contemplation of orthodontic problems; and the relation of service to its reward.

Brooks Bell,[3, 4] in two different presentations entitled "Office Routines," discusses the establishment of definite routines in handling what he terms the paper mechanics of an orthodontic practice as they relate to our patients.

When a new patient presents for diagnosis in Bell's office, the assistant places the patient in the operating room and fills out a case history card, listing the patient's name, birthday, parents' initials, address, and telephone number. Also noted on this card is the name of the person referring the patient. The assistant takes the card and checks the credit rating, which is noted on the back of the card in a space provided for this information. The card is filed for future reference. When reference is necessary, a reference slip is made out in triplicate—the original for the patient, a copy for the doctor to whom the patient is being referred, and a copy for Bell's own file.

Bell describes the method of appointment control from the chair by the use of symbols on the appointment card to designate the time interval between appointments, the amount of time to be reserved, and whether it is to be morning or afternoon. He also uses various colored pencils to designate that laboratory work is to be ready before the next appointment or that reference should be made to the family dentist before the next appointment.

Additional paper work discussed by Bell[3] includes the following: parents' or guardians' memorandum pertaining to orthodontic treatment; secretary's letter to accompany the memorandum; breakage letter relating to excessive breakage of appliances; case completed letter, original and two duplicates (one carbon going to the patient's dentist); retainer letter, sent at the time retainers are placed, which contains a statement that failure to wear the re-

tainer as directed, which evidences itself immediately on examination, will result in relapse and necessitate retreatment at the usual charge. This retainer letter also contains an admonition to visit the family dentist for a general checkup. (A carbon copy of the retainer letter is sent to the general dentist.) In his second paper[4] Bell also includes wisdom teeth extraction letter; maintainer letter; observation letter when space maintainer is removed; and transfer letter. All these letters are kept in a book for the secretary's reference so that they may be copied and sent as indicated by the circumstances with a minimum of dictation.

Anderson,[5] in discussing "Practice Management," emphasizes the importance of office location and arrangement of space; the establishing of definite times for consultation, at which hours no treatment patients are scheduled; use of an information card filled in by the patient before consultation, which has the notation at the bottom, "consultation fee --------"; matters that should be discussed with parents during the consultation period; and use of a pamphlet entitled *Information Regarding Orthodontic Treatment.*

Anderson uses a special card to inform the parents of their responsibility in the general care of their children's teeth. A letter confirming the financial details of the case as discussed with the parent is routinely sent. Anderson discusses the fee question and suggests a yearly fee basis as being the most practical during active treatment. An appointment charge, which is presumed to be on a service basis, is made for services beyond the estimated active treatment period. He illustrates various types of record forms used in his practice.

McCoy,[6] in a paper entitled "The Consultative Period," outlines the procedures for conducting the consultation, the matters to be discussed, the data necessary for the preliminary consultation, and those necessary for a complete diagnosis. He illustrates his article with various office forms, models, and photographs, as well as types of letters such as letter of agreement, which is sent when the first bill is rendered, and letter at completion of treatment, which outlines the duties and responsibilities of the patient during posttreatment care.

A compilation of data on the subject of economics in orthodontics by Harry Sorrells[7] takes the form of letters from an experienced orthodontist to a young orthodontic practitioner, answering questions relating to economics. The subjects covered are:

1. Supply and demand—areas for practice.
2. Social relationships.
3. Business.
4. Fees.
5. Foundation of fees.
6. Fees to other professional men.
7. Points to be considered in consultations.
8. How many cases can be handled.
9. Secretary.

10. Why a lower fee is not indicated.
11. Transfer cases—starting fee.
12. Transfer cases if treatment is to be changed.
13. Relation of gross income to operative expense.
14. Specialty board laws.
15. Examination—charges for.

This somewhat sketchy and probably incomplete review of published reports on orthodontic practice management indicates that much valuable information is available in the literature.

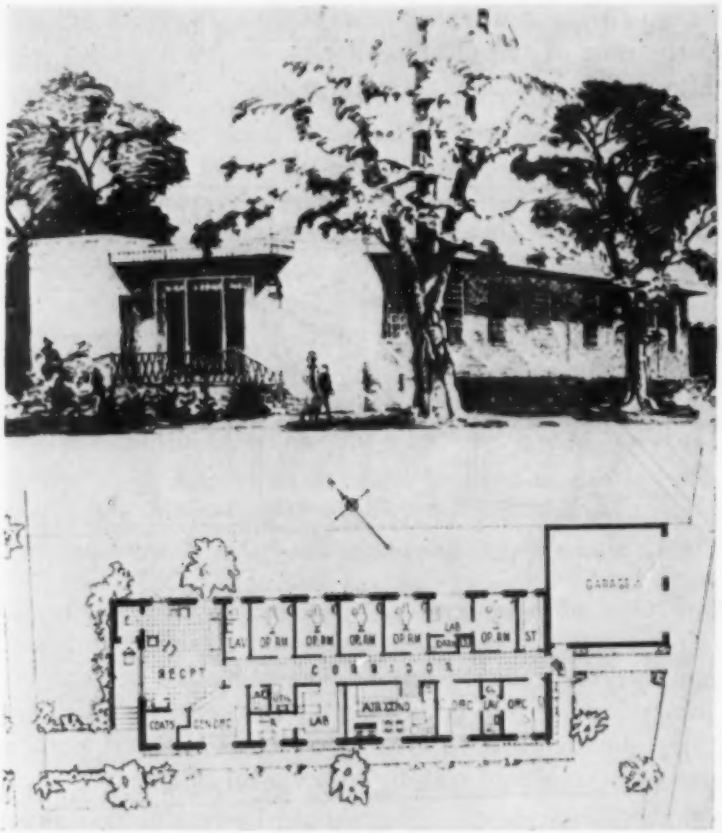

Fig. 1.—Office plan of offices of Oliver and Oliver reproduced from Am. J. Orthodontics 34: 291, 1948.

There are certain factors, which are important to practice management, that do not appear to have received the consideration they deserve. Anderson mentions office location and arrangement, stating that initial choice of both location and arrangement should receive careful consideration, but he does not elaborate on this statement. Let us consider office arrangement in more detail. The orthodontic office should be arranged in such manner that it is functionally efficient.

The office plan shown (Fig. 1) of the offices of Oliver and Oliver in Nashville, Tennessee, illustrates the type of planning that makes for functional

efficiency. The reception area is adequate and is under control of the secretary, whose office overlooks the entire reception room. The treatment area is adjacent and easily accessible, but is shut off from the reception room area by a door into the hall. The treatment rooms are on one side of the hall. The laboratory is across the hall from the treatment rooms, thereby making it accessible from any of the treatment rooms but sufficiently isolated to prevent interference from noise, odors, etc. Toilet facilities are arranged so that the destination of the child is not too obvious, an important psychological factor. Private offices for consultation with parents or conferences with fellow practitioners are located away from both reception and treatment areas, which assures privacy. Air conditioning and heating facilities are grouped in an area toward the rear of the office, and last, but perhaps not least, a two-car garage is attached, accessible through a door into the rear of the office building.

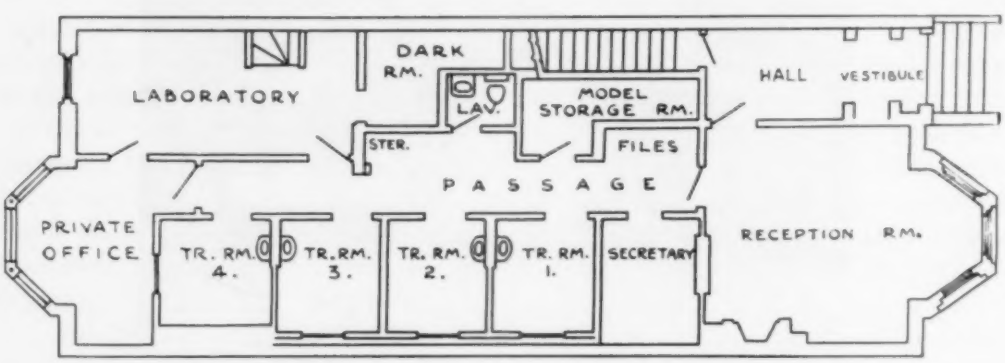

Fig. 2.—Office plan of author's office, a converted residence.

The floor plan of a converted residence is shown (Fig. 2) where the attempt has been made to establish functional efficiency in a similar manner, but on a considerably reduced scale. The objective of functional efficiency should go into planning individual treatment rooms and also the laboratory. The laboratory should have various work areas laid out with an eye to reducing unnecessary steps and making for over-all efficiency.

Colors for the orthodontic office should be restful and appealing. Good taste in color and arrangement can do much to add to the attractiveness of the office.

As Gibben[1] pointed out, efficient auxiliary personnel are necessary adjuncts to the effective conduct of an orthodontic practice. Whether one aspires to a setup such as Farkasch[8] describes in *Dilemmas of Dentistry,* where an executive assistant has complete administrative charge of the office together with such other personnel, hygienists, chair assistants, laboratory technicians, etc., as may be needed, or whether one has one person who performs all the auxiliary duties, we want, in so far as possible, to select the proper person.

A service is available in conjunction with credit bureaus of Personnel Selection Security Reports. These reports come in considerable detail, fur-

nishing the employment history of the applicant—names and addresses of employers, types of position held, competency, relations with fellow employees, reason for termination, eligibility for rehire; details regarding educational background; citizenship—loyalty; criminal record—any police or criminal record; personal history—marital status, dependents, former addresses, type of neighborhood, property ownership, how regarded as to character morals, honesty, and integrity; and suspicion of excessive drinking or use of drugs. The utilization of such reports saves much time in checking references and avoids the embarrassment of attempting to secure pertinent information by personal interview.

The first contact of the patient with the office is usually by telephone. The data to be secured at this time are name of the patient, name of parent or guardian, address, telephone number, and the name of the person who referred the patient. The secretary secures a complete credit report before the initial visit of the patient. File information as suggested by Bell usually is readily available, but such information relates to the paying habits of the individual and offers little toward the determination of the fee or the method of payment that would be equitable to the patient. A complete report gives one a better understanding of the economic background of the patient. One should learn to evaluate these reports, particularly in relation to the commitments the person may have, such as mortgages, automobile payments, radios, etc. Those who are too heavily committed in this regard may be fringe credit risks, even when they have substantial incomes.

At the initial visit, diagnostic data are secured as necessary and a future appointment is made for consultation. After the consultation, if treatment or observation has been decided upon, a confirmation letter and booklet are sent, as advocated by Bell, Anderson, and others. The confirmation letter may include the treatment plan, as advocated by Anderson.[9]

Whether the patient is to be under active treatment or observation, a method of appointment control is essential. In my practice a special form the size of the appointment book is used for appointment control. On the left-hand side of the form space is provided for the patient's name and case number. (Patients' names are added by case number rather than alphabetically to avoid bulk and are readily available for checking by cross reference.) Across the page from each patient's name is a series of twenty-four squares, each divided into four small squares. These twenty-four squares represent the twenty-four months in a two-year period and are so designated at the top of the page—January, February, March, etc. Active patients are checked each month against their treatment record and a small *a* is inserted in the upper left-hand smaller square for each month. Failure of a patient to appear in a given month is readily apparent and cross reference to the treatment record will show whether such failure was due to illness, absence from the area, a broken appointment, or any other reason. The utilization of such a form, which is incorporated as part of the appointment book, has the advantage of showing at a glance whether the patient under active treatment is making

regular visits. It also acts as a recall list for observation cases. When a patient is notified that he is due for recall, a notation is made in one of the small squares under the month of recall. If he comes in, he is checked off in the second small square of that month; if he breaks an appointment, that is noted; and if he changes an appointment, that is also noted. In this way a complete record of appointment control is readily available without the danger of lost or misplaced cards inherent in a card file tickler system.

H. F. Keister,[10] in a recent article on "Professional Business Management," states: "Your practice and your estate today are in jeopardy from social, political, financial, monetary, and even military influences over which you have only a remote control." In pointing out means of alleviating these pressures, he particularly emphasizes the necessity of having adequate and complete professional and business records. He advises that all incoming checks and cash be deposited and that all expense items be paid by check as income tax inspection protection.

Few professional men have the necessary knowledge of our complicated business and tax structure to personally train auxiliary personnel to properly handle the multiplicity of detail involved. Fortunately, there are organizations which can be employed to take over this onerous chore. The advantages of employing such an organization are many:

1. The establishment of acceptable accounting practices is of primary consideration.
2. Continuity of bookkeeping is valuable, and frequently difficult to obtain with changing office personnel.
3. A system of depositing all checks and cash and paying all expenses by check, including checks for petty cash, provides protection from income tax inspection.
4. Such organizations accumulate a vast fund of knowledge in relation to admissable deductions, from which the individual practitioner employing them profits.
5. They supply a monthly statement of income and expense. Income is listed by the current month and for the year to date; expenses are listed under their separate categories for the current month and by categories for the year to date. From time to time, percentage analyses of expenses are made and totaled to show the relation of expenses to net income. This allows the individual orthodontist to determine the essential data for determining fair fees for his patients, fair compensation for his auxiliary help, and a fair reward for his own services.

In closing, may I express the hope that in reading this article you have been stimulated to take a closer look at the economic side of your practice, as I have been in its preparation.

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106 MARLBOROUGH ST.

DEATH AND THE ORTHODONTIST

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FOREWORD

A NUMBER of years ago, a fellow orthodontist was killed instantly in an accident and I was asked to help his widow with the office. This I did to the best of my ability, but as matters progressed I encountered one ramification after another which had never occurred to me. By the time the whole problem was settled, I had thoroughly made up my mind that there should be made available to the profession some guide or procedural outline for such circumstances. It seemed best to let time pass so that I could look back on all the events with a better perspective. Now, it so happens, I have been helping with the practice of a friend stricken with polio. Again we have a similar problem presenting itself. While the man is still very much alive and will return to his practice, he has of necessity been completely unavailable for all practical purposes. While these are my only personal experiences, I have discussed the general situation with as many other men as possible who have met this dilemma.

In writing this article, I searched the dental literature of the last thirty-five years and could find no literature on this subject in periodicals or texts. Medical literature produced similar results. However, the Law Library of the Supreme Court of the State of California disclosed several similar references. They are similar in that a legal case may be contracted for in advance, the services are personal in nature, and the services may extend over a considerable period of time. The issues raised on the death of a lawyer are therefore similar. I am advised by competent legal authority that my legal quotations herein are therefore applicable in our case. I should like to point out, however, that there are several hundred thousand lawyers in America, but only a few orthodontists. Ponder this point, for this can prove to be a real problem when we lose one of our number.

THE PREVENTIVE MEASURES

An elderly but vigorous orthodontist once remarked to me that he stayed youthful because he was concerned primarily with the problems of youth, and that contact with them kept him from aging. So it is with most of us. Spending our days with youngsters gives us very little reason to contemplate the

This thesis, which was given as a partial fulfillment of the requirements for certification by the American Board of Orthodontics, is being published with the consent and the recommendation of the Board, but it should be understood it does not necessarily represent or express the opinion of the Board.

problems of old age or death. A careful perusal of our journals will disclose the answer to almost any problem of practice. Still, there are some problems at the end of a career which are not so easily solved. Few people in the prime of an active life consider that they may be taken in a sudden accident or struck down by a serious illness.

Generally speaking, the desire for security is strong in all of us and each has cared for this in his own fashion—that of the family by adequate life insurance; that of self by health and accident insurance. We work in community projects, we take graduate courses, we do many things to improve our standing and consequently make our positions more secure. But which of us ever really considers that he may be unexpectedly taken and his beautiful office and fine practice thrust upon his widow, not as part of a desirable estate, but as a real liability with ramifications beyond his worst nightmare?

There are really three very good reasons for any of us to give more than passing thought to the disposal of a practice. First, we are professional men and we are obligated to conduct ourselves so that the best interests of our patients are protected. No one should practice from day to day thinking of death, but he certainly should so handle matters that another could step in and take over with a minimum of confusion and delay. Second, we have contractural obligations to fulfill and whenever a prepayment occurs the rules of equity govern our estates. Third, even in those practices where no contractural obligations exist, a tangled financial picture is an unfair burden to pass on.

In a discussion of the problem of death and the orthodontist, there should be reference, of course, to solution of the pertinent problems in those instances wherein no preparation has been made. In the midst of her bereavement the widow may be called on summarily to handle problems definitely beyond her scope. To whom shall she turn—a dentist friend, a lawyer, a dental supply dealer, another orthodontist? How shall she handle the financial problems? Should she make refunds in certain instances? What of the technical problem of the replacement? Here may be a solution to many of the other questions but, above all, let me impress upon you now that your fine practice, netting thousands of dollars per year, at your death becomes an actual liability or, at most, salable for the bare value of the equipment (and not your valuation either). Rare is the widow who is fortunate enough to get more.

Obviously, the best solution to any problem is to have perceived the problem in advance and, by proper prearrangement, to have completely eliminated it. Perhaps we cannot all do this, but a systematic check of cardinal points will surely reduce the most troublesome items. First, each of us should conduct his practice on sound business principles. That sounds clear enough, but what does this mean? Probably the most important single step toward good management is to keep good records. That means good business records of the financial side of the practice and complete case histories and treatment records of the patients. I dare say that not one orthodontist in 100 knows how to set up a system for financial records, and few can carry on well once a system is established. By far the majority of us have a catch-as-catch-can card system

or ledger book which we hacked together ourselves or which some older man suggested. Right at this point, ask yourself, "What is my net worth? What are my current net assets at the office? Could I strike a trial balance?" Let your auditor or accountant see what you are doing, and ask his advice on how to set up a proper record. If you do not like his suggestions, or if they seem too complex to follow, investigate one of the organizations which specializes in teaching the dentists' business to dentists—Professional Budget Plan and the Boswell course to name two. Even if you can juggle figures as easily as you bend a wire, let an expert see what you are doing from time to time and accept his suggestions.

It seems almost redundant to mention a will, since we are told so frequently about the need for one, but this step should be high on your list of preventive measures. Another excellent preventive measure is the preparation of a detailed list of instructions as to where valuable papers are, how certain details are to be handled, how the life insurance is to be worked out, and other similar instructions. The American Association of Orthodontists has recently supplied each member with an excellent booklet for just this purpose, entitled *For —— From the Necrology Committee of the American Association of Orthodontists.* In a recent article Dr. J. C. Almy Harding[1] has suggested a loose-leaf notebook entitled *Handbook of Resources* to help solve this problem. His suggestions for information to be included are similar to those in our booklet. Such records as these should not be made and then forgotten, but should be checked from time to time just as we review our wills or our life insurance policies. They should then be revised and brought up to date.

And now to case histories and treatment records. What a subject! In school we were all clearly shown the value of good patient histories and complete treatment records. How many of us would like our files thrown open to the critical eyes of our old instructors? As valuable as records are to you in life, they are even more important should you not be there to interpret them when someone else must shoulder your burden. I believe that it would be a waste of time to tell how to keep treatment records beyond saying that any way chosen is perfectly satisfactory, provided that the records are kept faithfully and that they are readily understood by another person. This does not mean that we must have the detailed treatment plan advocated in textbooks, but we should include a summary of our plans for each case. On the other extreme, a case history filled with cryptic symbols or equally mysterious notations, such as "adj. appl.," and "str. ad.," certainly gives little clue to what the operator intended. Durand and Morgan[2] have this to say about records: "Obviously a record is of the greatest possible assistance when further treatment is required, for the dentist can see at a glance what has already been done and when it was done. Naturally any appropriate remarks about any particular item of treatment should have been entered on the treatment card. A record card, if it is to be useful, must be of adequate size and contain sufficient space for all the appropriate information. A small card may be easy to handle, but it is of little value if it provides insufficient space for the recording of full and proper information. Records should be clear and

legible so that they can be understood not merely by the person who made them but also by others. They should not be in the form of a personal, and to others indecipherable, code or shorthand. We do not suggest any particular dimensions for the record cards, for that is a matter of individual taste, but merely indicate the type of information which it is useful and desirable to record.'' On the subject of records, while it is the primary intent of this article to cover the value of records in case of death, they are equally, if not more, valuable in case of illness. Should you become ill, even if your best friend or your fellow members of a study club take over your practice, it will save them much valuable time if the records clearly show the past procedures and future intention of the operator. Recently I have had the experience of carrying on, with two friends, the practice of a fourth friend. Fortunately, he had good, legible records, which greatly simplified the task. We, in turn, have attempted to keep good records so that each of us may know what the others are doing.

Regarding financial arrangements with patients, it is a fact that if a fixed fee is agreed upon by patient and dentist, the death of the dentist may bring about misunderstandings between patients and the estate. The obvious answer is to consult your lawyer about your particular payment plan and your contract arrangement to see just what your position might be in case of severe illness or death. Any lawyer will tell you that most of his clients' troubles could have been prevented if they had consulted the lawyer before taking certain steps. Indeed, an attorney's fee for consultation or advice is often just a fraction of his fee for extricating a client from many situations which could have been prevented with forethought. In the event that flat fees are used, it is wise to set up your books so that they constantly reflect the relationship between the amount of work accomplished and the payments, so that an equitable refund may be made in certain cases, or so that the estate may establish that service has been rendered in sufficient quantity to justify the amount paid. In addition to the previous suggestions, a further wise move would be to have an adequate financial reserve earmarked for this purpose or a special life insurance policy to care for this contingency.

Now, the problem arises as to what amount might be necessary to handle this situation. Obviously, no one solution will fit all cases. First of all, each of us should do a little introspecting and ask ourselves how our cases, our records, and our business procedures would look to another orthodontist, perhaps a total stranger. What is the availability of other men who might help out our widows? A man practicing in a metropolitan area has far less of a problem than one in a remote area. Examine your own practice and see about how much in unearned assets is on your books. It is a generally accepted procedure among orthodontists to request an initial payment or starting fee. This may be compared to the lawyers' retainer fee but, like his retainer, it is not earned until work is accomplished. Certainly then, if one starts six cases per month and has an initial fee of $150.00, at least that amount of money should be in reserve. Probably most of us take more than one month to

actually get a case under way, so the sum total of starting fees for several months would probably constitute a safe financial reserve for this purpose.

Another method of approach to the total problem of protection for the estate would be to consider the preceding as part of the total insurance needs of the individual. We are somewhat in the position of a small business, in that we produce and market our own ability and skill. There are many methods of so evaluating a business, but a simple, widely used scheme is to multiply the net annual income by ten. Hence, a business or practice netting $10,000.00 annually is reckoned to be worth $100,000.00. A businessman's family may expect to sell the firm for some amount based on this valuation because there are many things, such as inventory, involved. We cannot do this, so our problem is thereby increased and we must indemnify our estates by insurance or other means. We have little to sell except our equipment, as it is generally held that the personal good will of a professional man cannot be sold or transferred. Upon his death his personal ability, skill, and integrity die with him 100 per cent.[3]

Another way of looking at the total problem would be to view your practice in light of what all courts hold to be a "fair market value." This value has been defined as "the price at which property would change hands between a willing buyer and a willing seller, neither being under any compulsion to buy or sell." Just think that one over! You probably wouldn't sell your practice for a great deal, but just how much do you really think you could sell it for if you were present? Again, this figure may be used as some clue to the proper amount of insurance to safeguard the value of the practice.

THE DISPOSITION OF A PRACTICE

The second part of this article will attempt to deal with the much more difficult problem—those cases wherein death strikes and no preparations are made. The following remarks are primarily intended as guidance for a widow, but they might be used by anyone who would be called upon to settle the estate of an orthodontist.

First, before any steps are taken, the services of a competent attorney should be secured and he should be retained on an advisory basis until such time as the estate is completely closed. While this may seem to place undue or unnecessary emphasis on the legal aspects of the problem, I do not believe that too much attention can be focused on this point. It should be noted here that it is unlikely that the attorney will be able to render advice on the technical aspects of the practice, but he still should be called in for counsel on all phases of settlement. We cannot and should not try to tell the lawyer how to do his work but, since he probably will not handle many such cases, it might be wise to apprise him of the special problems outlined here.

Second, an auditor should be employed to go over the financial records. This is a very important point and should be done within one week. Time is of the essence here and the widow should be so advised. It is all very well to let some of the other affairs rest until she recovers, but either she or her

lawyer should be alerted on this action. The auditor should be instructed to get control of the records and to locate the accounts receivable. He must somehow determine the assets at the time of death, and he must deposit the cash on hand and get a trial balance for the accounts. I venture to say that few of us alive can produce records within a week which would allow these pertinent facts to be drawn from them. This is a necessary step in order to comply with the provisions of a tax law passed in 1942 to assist dentists.[4] The Revenue Act of 1942 provides that, for purposes of figuring income tax for a decedent, the sum shall include only the amount received up to the time of death. Then that money which comes in subsequently will be taxed as it is received by the heirs or beneficiaries of the decedent.

At this point it should be mentioned that it would be highly advantageous to secure the continued services of the principal assistant in the office until the exact disposal of the office is settled. A wise move would be to contract for her services as soon as possible and attempt to insure her performance by whatever means necessary. In some instances loyalty may be enough; unfortunately, most human beings are guided by stronger motives and the need for future employment may influence this person to leave the position at a time when she is vitally needed. Therefore, I strongly recommend the proffer of a financial reward as the best means of holding the continued interest of this person.

Now comes the $64.00 question: Whom shall the widow turn to? Shall she be advised by her lawyer, a dentist friend, another orthodontist, or the dental supply man? Certainly she will need advice. Any woman confronted with all the problems of a full practice is going to need help. It might be well to state right here that if she can transfer the whole practice to another orthodontist who will assume responsibility, that is the ideal solution. Unfortunately, a spare orthodontist is not usually found hanging around. To repeat an earlier point, the widow should be properly informed on the true value of the office. A recent settlement of a West Coast office highlighted this point. When the orthodontist died, a very competent attorney was chosen for the advisory position; he studied the financial statement and, seeing the large gross and net income enjoyed by the deceased, promptly applied the rules of a going business to his thinking and came up with a very high figure as the value of the practice. In actual fact, the other orthodontists in the area had an extremely difficult time in distributing the patients among themselves, as few men even wanted to assume responsibility for the cases. Hence, someone conversant with our problems would be the ideal person to advise.

Any one of us should be willing and anxious to render assistance in such an unfortunate circumstance. The widow should be carefully counselled as to her advisor or advisors, but once he or they are selected, they should be allowed to do their best without outside interference. We should all be careful in commenting on such advice unless we know all the circumstances involved.

Probably the very best solution would be to have two or more fellow orthodontists review the practice and make necessary recommendations. If at

least two orthodontists could review the cases in a practice, they could quickly determine the magnitude and nature of the problem. They should determine accurately the number of active cases, the number of retention cases, and the quantity of new work in hand. This information is invaluable when presenting a true picture to a possible successor. The local men should be apprised of the situation and given an opportunity to assume the responsibility. If no one locally can assume the practice responsibility, then steps should be taken to try to reach a qualified man to replace the deceased. If a man is found to assume the practice, a clear-cut agreement should be drafted by the attorney, whereby the estate is relieved of all responsibility, past or future. This assumption of responsibility should be considered in a large way as a valuable contribution toward the purchase price of the practice. The agreement must also state the period of time that the successor may use the name of the former orthodontist on the door and on the stationery. This period varies from state to state and should be determined locally.

In so far as determining a fair price for the office, any dental supply dealer can and will give a good appraisal of the physical equipment. The appraisal valuation of the physical equipment, the instruments, and the inventory of the office should be the principal consideration in establishing a selling price. Now, this statement may be considered highly controversial by some readers. Let us investigate what we are discussing selling beyond these items. By "physical equipment," we mean our dental chairs, desks, cabinets, x-ray machines, typewriters, and other such items; our instruments are a few pliers, wire cutters, and scissors, the total value of which is insignificant in relation to one dental chair, for example; the inventory is our stock of gold or stainless steel.

Then what else is to be sold? The practice? Just what is the practice? It is a group of patients who have sought the services of a man because of his reputation and ability. But his ability, skill, judgment, and integrity have passed with the decedent.

Kester[5] says, "It should be pointed out that only those elements which are transferrable and are transferred can be disposed of for a price. Thus when a business goes to a new owner as in the case in transfer of some professional businesses, goodwill may not be worth much to a prospective purchaser."

Paton[6] says "It may be feasible in such a purchase to make a small allowance for goodwill, on the ground that the acquisition of the name and the location, together with the control of current business, will bring in some business through clients' force of habit if for no other reason."

Kester[7] further states that "goodwill includes every advantage connected with location, premises, reputation, personality, name and so forth." I include this definition because it came as some surprise to me. In other words, in the eyes of people whose business it is to handle these matters, it is the orthodontist himself who has value, and not very much else.

Of course, the amount of money due the estate in accounts receivable should be set forth by the auditor and an understanding reached as to how these funds will be transferred to the estate as they are paid into the office.

The accounts receivable may be handled in several ways: the successor may collect them and turn them over to the estate as received, or he may elect to pay a total amount for them based on collection experience of local collection agencies.

From time to time an exceptional practice may change hands differently, but most of us should be satisfied if our widows can receive the money due under accounts receivable, be relieved of all responsibility for the practice, and be paid a fair price for the actual equipment. True, from an accounting standpoint, it is held that good will has a small valuation, but overriding this is the importance of being free and clear of responsibility. If you think your practice is worth some large amount, think of it realistically; it is you who made it so. Forget the income from the practice as a tangible asset and remember it is you and your efforts that make this possible. If one places a high value on his practice, then let him insure his life for an additional amount of life insurance to compensate for the loss of the practice. This insurance may be earmarked for this purpose and used to settle the office, then let the residue enter the estate, as stated previously.

A very difficult question sometimes arises at this time when attempts are being made to settle the estate. It has actually happened that parents of patients have demanded that the estate pay for the conclusion of their work, holding that the estate was responsible for the unfinished work. I quote directly from the pertinent legal source 5 *American Jurisprudence,*[8] Attorneys at Law, Section 41: "A contract of employment for legal services is personal in its nature and terminates upon the death of the attorney employed. Even the death of a member of a firm may terminate a contract for the employment of the firm if the contract was made with the understanding that the services were to be rendered by the deceased member. However, one member of a law firm cannot, upon the death of another member, refuse to carry to completion executory contracts which do not call for the individual personal services of the deceased partner." This is thoroughly annotated and applicable to an orthodontic practice. As you read this, if you are conducting a practice in partnership with another, the last sentence has particular significance for you.

It may well be, however, that certain refunds are unavoidable. If refunds must be made, the law governing them may be found in 5 *American Jurisprudence,*[9] Attorneys, Section 201, page 283. It states: "Where the contract between an attorney and his client is terminated by the death of the attorney, the extent of the recovery permitted his representative is the full reasonable value of the services rendered prior to the death, not exceeding, however, the sum or rate fixed by the contract. The contract may be of value in determining the reasonable value of the services, and the compensation may be apportioned in such proportion as the services actually rendered bear to those contracted for." This emphasizes a point made previously that it is important that one's records show the progress of the work as related to charges made. In other words, refunds may be necessary to satisfy the just claims of patients for services not rendered. It is well to act slowly on this matter, even though

some refunds are clearly advisable. The payment of one or two refunds in haste may start a run through the same psychology as bank runs occur. It is perfectly fair to ask patients to wait until the estate is settled. When a satisfactory successor can be secured, the whole problem of refunds may be solved when the practice is continued as before.

In attempting to find a man who will carry on the practice, no stone should be left unturned. The widow should be assisted in this endeavor by her advisor or advisors. While it is important to get the best man possible, it is very essential that he be secured as soon as possible. In those cases wherein a satisfactory successor is found, the legal documents recording the transfer of the office and practice from the estate to him should clearly indicate that his acceptance of responsibility is a recorded fact and is to be construed as a positive contribution.

If it should become evident after a passage of some period of time that no one is going to be found, then the patients will have to be told to make the best arrangements they can for themselves. In the few instances wherein this happens, much confusion invariably ensues. The widow is subject to needless stress and the patients are left feeling adrift. This is an unfortunate situation and we should all strive to prevent this from occurring.

As the reader peruses these lines he will probably be thinking, "This couldn't happen to my wife. I'll take care this doesn't go on; what kind of an orthodontist is he writing about?" Gentlemen, this could be any one of us.

As stated earlier, prevention is the best cure. We should conduct our practices along the lines of some generally recognized appliance therapy. We all know that there are differences in appliance therapy. We all know that there are differences in appliances used today, but this is no reason not to adopt one technique or another and adhere rather closely to it. Each of us knows if he is proceeding along lines of conduct of practice as espoused by some group or if he is using a hodgepodge appliance therapy that no one else could fathom. Let your conscience be your guide!

SUMMARY

To summarize the preventive measures:

1. Follow good business procedures and keep adequate financial records.
2. Consult qualified accountants or auditors for advice and checkup.
3. Consult the attorney who prepares your will regarding your customary financial agreements with contracts to eliminate potential trouble spots.
4. Maintain adequate liquid reserves or special insurance to cover any necessary refunds.
5. Keep understandable treatment records and case histories.
6. Practice along the lines of some recognized appliance therapy.
7. Have a check list of vital information complete for your executor's information.
8. Have a will.

In summary of those cases wherein death or serious illness removes the practitioner and others must settle his affairs:

1. Retain a competent attorney until the estate is settled.

2. Secure the services of an auditor to get control of the records and locate the accounts receivable.

3. Make definite arrangements to continue the employment of the principal assistant until all problems are settled.

4. Select advisors for disposal of practice—preferably two or more orthodontists.

5. Have appraisal made of physical assets in office.

6. Attempt to secure a successor.

7. Be sure that the practice responsibility is properly assumed by the successor.

CONCLUSIONS

A great many of the most quoted sayings in the English language tell us to take care of necessary things in due time. There are "an ounce of prevention," "a stitch in time," "locking the barn door," and so forth. Each of us should keep his own house in order. But, further, we are "our brother's keepers," and should all stretch forth the hand of assistance when illness or death strikes one of our fraternity.

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CRANIAL BASE DEVELOPMENT

A Follow-up X-ray Study of the Individual Variation in Growth Occurring Between the Ages of 12 and 20 Years and Its Relation to Brain Case and Face Development

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DURING the latter period of the prenatal stage the cranial base, which develops essentially from the chondrocranium, consists of a number of individual bones which possess a certain amount of mutual freedom of movement. Because of the articulation between these various bones, the shape of the cranial base during this developmental period may vary considerably, with a general tendency to straighten out, which will continue up to the time of birth. During the first years of childhood there is a gradual bending of the cranial base which continues up to the age of 10 or thereabouts. At this stage, the brain case has practically reached its final volume and the cranial base is usually considered to have reached its final shape.[19, 22, 23] Considerable age changes in shape, however, take place also during adolescence, as I have shown previously.[3]

Although the literature deals extensively with the variation in shape of the face and skull, comparatively few investigations have been made to determine the variations of the cranial base formation in human beings[1, 2, 16, 20, 29, 31] and very few deal with the individual development with age,[3, 9] despite the general recognition of the phylogenetic importance of the shape of the cranial base.[6, 10, 12, 25, 28] Longitudinal studies of human growth have often been treated in much the same manner as cross-sectional material and hence the individual variations in development have not been given the prominence they deserve.

The aim of the investigation is to obtain a quantitative estimate of the magnitude of the individual growth changes during the adolescent period as a whole and their correlation with the development of the brain case and the facial structure.

Shape is a function of growth, and the connection between variations in shape and variations in growth is a question about which relatively little is known. The present article also takes up this matter for discussion.

MATERIAL AND MODE OF ANALYSIS

The present analysis of the individual variations in the growth pattern of the cranial base is restricted to the adolescent growth period. The investiga-

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tion is based on measurements obtained from orientated lateral head x-ray films covering an arbitrary selection of 243 12-year-old Swedish boys who were later subjected to a follow-up study using the same method at the age of 20.

A detailed description of the x-ray method employed will be found in earlier publications.[1, 2]

In order to obtain a well-defined picture of the soft tissues of the profile, a wedge-shaped aluminum filter was placed between the patient and the film at the re-examination. A similar filter also may be placed horizontally at the

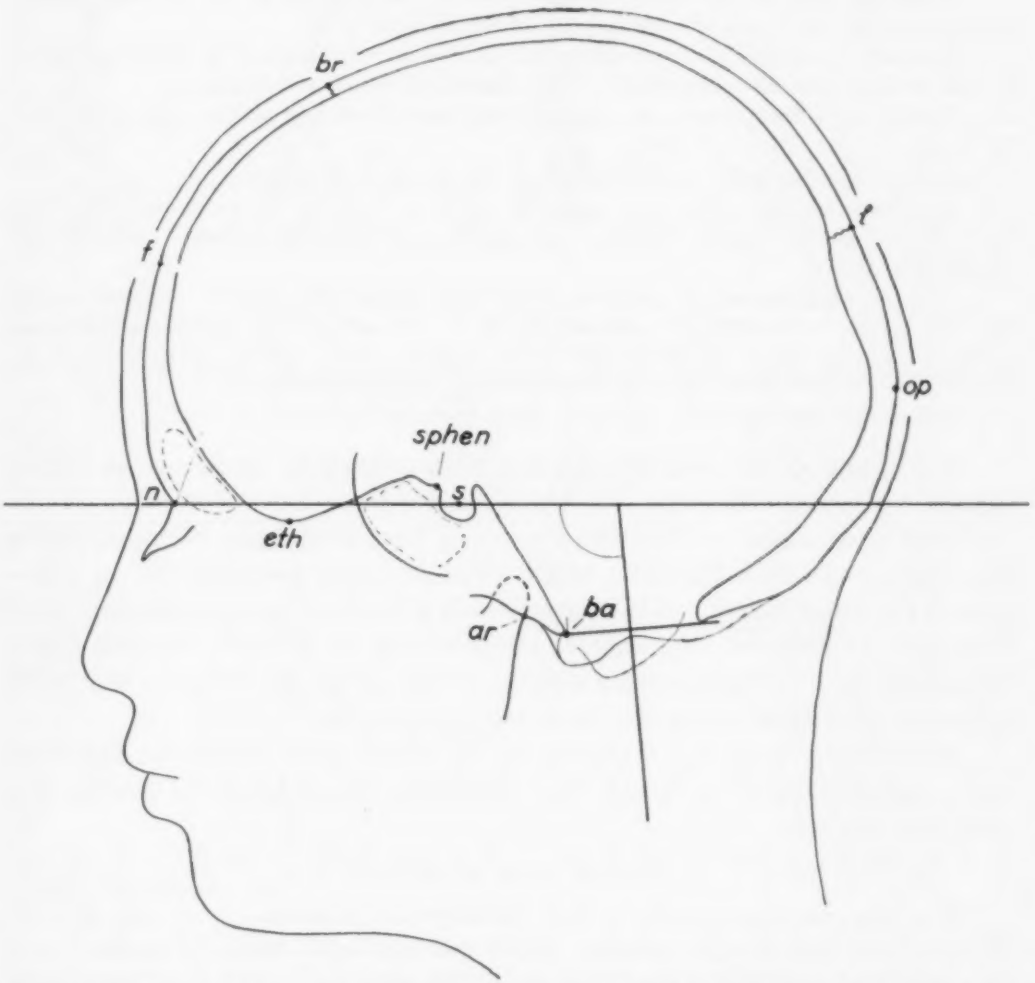

Fig. 1.—Reference points on lateral head x-ray photographs within the cranial base and the brain case.

level of the neck to increase the contrasts of the larynx. A method developed in order to bring out the soft tissues of the mouth on the film involves the use of tantalum powder. An application of a suspension of this powder in water to the tongue and gums serves to produce a sharply defined outline of these parts on the film, without in any way impeding the function of lips and tongue.

Following is a set of definitions of the reference points on the cranial base and in the brain case which I have used for the purpose of x-ray measurements in this study (Fig. 1).

Articulare (ar)—Point at the junction of the contour of the external cranial base and the dorsal contour of the condylar process. (The mid-point is used at double contouring of the condyles).

Basion (ba)—The perpendicular projection of the anterior border of foramen magnum (endobasion) on a tangent through the lower contour of the foramen.

Bregma (br)—The junction of sagittal and coronal sutures on the surface of the vault.

Ethmoidale (eth)—The lowest median point of the contour of the anterior cranial fossa, corresponding to the cribriform plate of the ethmoid bone.

Frontale (f)—A point on the surface of the frontal bone defined by a line projected at right angles from the mid-point of a line connecting nasion and bregma.

Lambda (l)—The junction of lambdoid and sagittal sutures on the outer surface of the vault.

Nasion (n)—The most anterior point of the nasofrontal suture.

Opisthocranion (op)—The most posterior point in MSP on the outer surface of the vault, defined as the largest distance from nasion (excluding the external occipital protuberance).

Sella (s)—The center of the bony crypt forming the sella turcica. The surface of the sella turcica is determined independently of the contours of the clinoid processes, and is limited upward by a line from tuberculum sellae to dorsum sellae. The center is defined as the mid-point of the greatest diameter from tuberculum sellae.

Sphenoidale (sphen)—The uppermost point of tuberculum sellae in MSP.

The shape of the cranial base has been defined in terms of the angles formed by nasion-sella-basion and nasion-sella-articulare. The slope of the forehead is expressed by the angle formed by lines joining the reference points frontale-nasion-sella. The head balance axis is drawn perpendicular to a tangent to the lower contour of the anterior and posterior border of foramen magnum, the foramen line. The balance of the head is given by the foramen angle, formed by the head balance axis and the n-s line (Fig. 1). Linear x-ray measurements are defined in terms of their reference points.

In order to obtain some idea of the development in width, the follow-up study included dental casts and direct measurements of head and face by conventional methods.

AVERAGE GROWTH PATTERN

For the purpose of growth and developmental studies, the head may be divided into four distinct zones. These are the brain case, the upper facial structure, the mandible, and the intermediate zone formed by the cranial base. In the case of the brain case, the rate of growth of the inner structure is governed by the growth of the brain. After the age of 10 or 12 years the increase in size is slight, whereas the facial skeleton, comprising the bones of the upper facial structure and the mandible, continues its growth up to the age of 20 and beyond. The cranial base, which from a functional point of view may be regarded as the border between brain and facial structure, is obliged, therefore, to develop in conformity with the different growth patterns of the brain

case and facial structure and, consequently, must follow two different growth rates, one along its internal surface and another along its external surface.

The mode of growth of the cranial base emerges quite clearly from the series of cephalometric x-ray pictures, representing the same selection of individuals at various ages.

Figs. 2 and 3 illustrate the growth mechanism of the cranial base, showing a comparison of x-ray films taken at different stages of development in which the nasion-sella line is coincident and commences at the center of sella turcica.[8, 9]

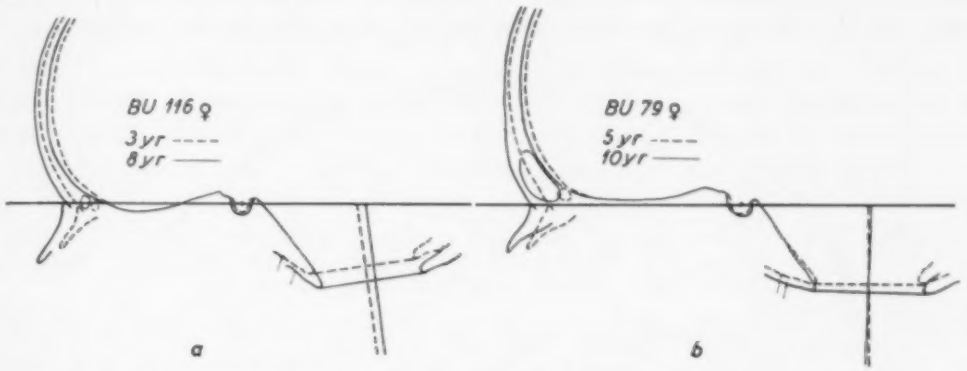

Fig. 2.—Growth pattern of the cranial base during childhood, exemplified by two cases; (*a*) from 3 to 8 years, (*b*) from 5 to 10 years of life.

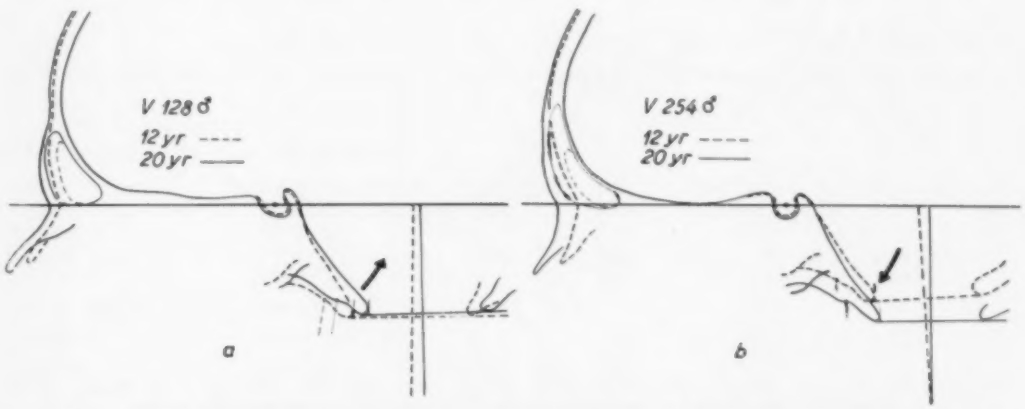

Fig. 3.—Variations in growth pattern of the cranial base during adolescence, 12 to 20 years, illustrated by two cases (*a*) with decreasing and (*b*) with increasing deflection of the cranial base during growth.

During childhood the anterior portion of the cranial base gains in length by a process of sutural growth and thus keeps step with the growth of the brain. As the extension of the anterior cranial fossa gradually ceases around the age of 10, the continued longitudinal growth of the upper facial structure is compensated mainly by the formation of bone tissue on the outer surface of the frontal bone.

The differentiated growth mechanism of the anterior portion of the cranial base during the early and late periods of postnatal development is illustrated in Figs. 2 and 3. The progressive increase in length of the anterior cranial

fossa during childhood is the result of a ventral displacement of the frontal bone as a whole (Fig. 2, *a* and *b*). It will be seen from the x-ray drawings that there is a ventral displacement of the outer and inner contours of the frontal bone, as well as those of the frontal sinuses.

The appositional growth of the bone structure in the glabella region, which occurs subsequently in order to compensate the continued longitudinal growth of the upper facial structure during adolescence, is illustrated in Fig. 3, *a* and *b*. The median contour of the anterior cranial fossa will, therefore, largely remain unaltered between the ages of 12 and 20 years. However, this statement, which will be re-examined later on, is valid only for the ethmoid part.

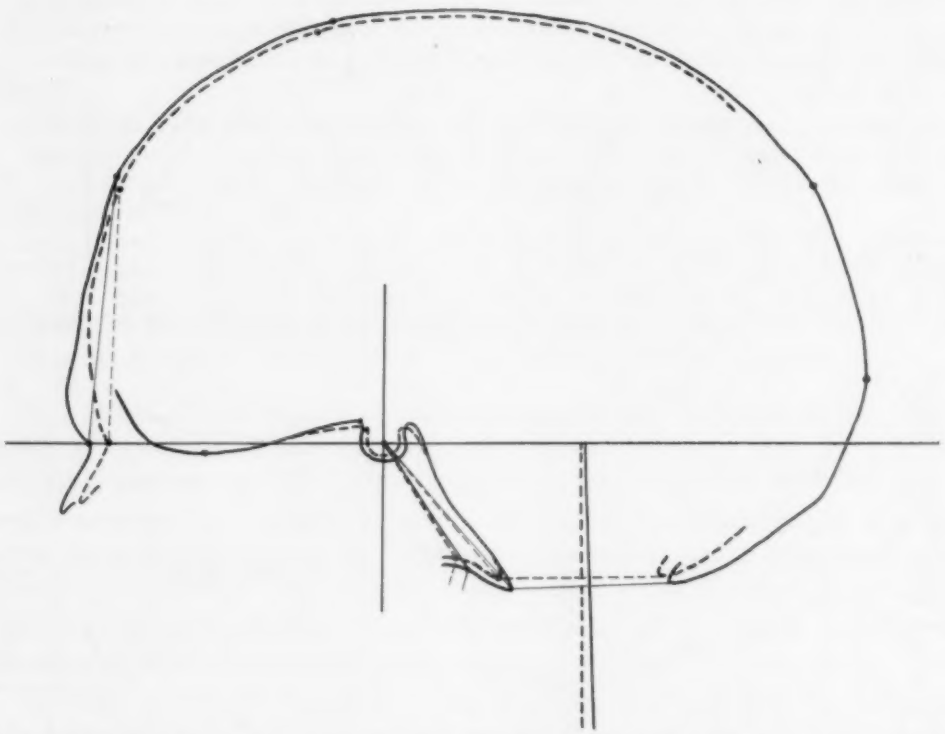

Fig. 4.—The general growth pattern of the cranial base and the brain case from 12 to 20 years of age in the same individuals. The sample comprises 243 cases.

The ventral bodily displacement of the frontal bone appears to have ceased at this stage, and the distance between sella and nasion is increased only by the process of frontal apposition, resulting in the development of the glabella region and of the frontal sinuses, at the same time as the forehead becomes recessive. The angle of the forehead, given by the angle frontale-nasion-sella, has been found to diminish in all the 243 cases examined, with an average diminution of −3.6 degrees (Fig. 4) and a standard deviation of 1.3 degrees. Of all the angles measured in the head and face, this is the only one which exhibited individual changes in the same direction only with age.

All the other angles within the cranial base and the facial structure showed individual changes with age in both directions, as already indicated in a pre-

liminary report on the investigation.[3] This matter will be brought up for discussion again in the present article, but it can be stated here that the mean values of the changes that take place with age will be relatively small, despite the fact that the individual changes may be considerable.

The growth mechanism relating to the dorsal part of the cranial base is of a different nature, however. Here the medial region increases in length due to the growth at the spheno-occipital synchondrosis, the basilar part of the occipital bone, being displaced dorsally with the result that the distance between sella and foramen magnum or the reference point basion increases. The elongation of the frontal and dorsal portions of the external surface of the cranial base is therefore found to remain sensibly proportional during the growth period from 12 to 20 years, on an average 5 and 4 mm., respectively, although the increments are due to a different growth mechanism. The relevant statistical figures are to be found in Table I and are illustrated in Fig. 4.

TABLE I. MEAN VALUES FOR CRANIAL BASE AND BRAIN CASE MEASUREMENTS AT THE 12-YEAR (M_{12}) AND 20-YEAR LEVELS (M_{20}) IN THE SAME INDIVIDUALS, THE MEAN OF THE AGE DIFFERENCES (M_D), AND THE STANDARD DEVIATIONS (S)

VARIABLES:	M_{12}	S_{12}	N	M_{20}	S_{20}	N	$M_D \pm \epsilon$ (M)	S_D	N	S_D/S_{12}
Cranial base angles (in degrees):										
n-s-ba	130.8	4.2	223	131.6	4.5	234	0.7 ± 0.13	1.9	223	0.45
n-s-ar	123.1	4.6	243	124.2	5.1	243	1.2 ± 0.14	2.2	243	0.48
Forehead angle (in degrees):										
f-n-s	88.1	3.1	137	84.5	3.2	243	−3.6 ± 0.11	1.3	137	0.42
Foramen angle (in degrees):										
(head balance axis to n-s line)	90.4	4.7	171	91.8	5.1	224	1.2 ± 0.17	2.2	171	0.47
Cranial base dimensions (in millimeters):										
n-s	68.8	2.8	243	73.7	3.3	243	4.9 ± 0.09	1.4	243	0.50
s-ba	45.2	2.6	219	48.9	3.0	234	3.8 ± 0.12	1.8	219	0.69
n-ba	103.9	3.8	219	112.0	4.4	234	8.1 ± 0.15	2.3	219	0.61
s-ar	34.4	2.9	243	37.6	3.1	243	3.2 ± 0.10	1.6	243	0.55
n-ar	92.0	3.8	243	99.5	4.4	243	7.5 ± 0.13	2.0	243	0.53
Brain case dimensions (in millimeters):										
f-s	92.3	3.8	137	94.9	4.3	243	1.5 ± 0.10	1.2	137	0.32
br-s	103.8	2.8	134	106.5	4.6	243	1.3 ± 0.12	1.4	134	0.50
l-s				125.6	5.6	243				
br-ba	143.7	4.0	121	149.5	5.4	234	4.0 ± 0.20	2.2	121	0.55
n-br	115.4	5.0	138	121.6	5.6	243	4.3 ± 0.15	1.8	138	0.36
n-op				196.2	7.2	242				
br-l				128.4	7.4	243				

N—Number of cases.

The growth increment which takes place in the spheno-occipital synchondrosis only serves to elongate the clivus. As a result of sutural growth, however, a dorsal elongation of the lateral portions of the cranial base and of the brain case also occurs, parallel with the elongation of the clivus. The sutural growth appears to remain active in greater or lesser degrees as long as the facial structure continues to grow. According to Büchi,[11] growth of the facial structure continues beyond adult age, although the rate of growth may be very slow. The temporal bone, and with it the glenoid fossa and the mandible, thus

suffers a dorsal displacement in relation to the frontal portion of the cranial base, effecting a rearward extension of the junction between the cranial base and the facial structure. The net result of this is a ventral and dorsal increase in the junction between the cranial base and the facial structure, which causes the distance between nasion and the jaw joint to increase, on an average by 7.5 mm. The dorsal elongation of the lateral regions of the cranial base has the effect of bodily displacing the mandible backward, on an average 3 mm.

The posterior and the two median cranial fossae increase considerably in size in relation to the anterior one, as will be seen from the age changes in the cranial radii (Table I and Fig. 4). The effect is also to lower the median and posterior cranial fossae in relation to the frontal part of the cranial base, that is, to the anterior fossa. The height of the brain case, measured from bregma to basion thus increases on an average by 4 mm. The marked change in the cranial radii which takes place during the growth period is too big to be attributed merely to a thickening of the calva. Comparing the x-ray films reveals that the internal measurements vary in a corresponding degree, although it is difficult to establish these measurements for practical reasons. This displacement of the posterior and median cranial fossae during the growth period may be described as a lowering of the cranial base periphery around the sella region.[13, 29] The petrooccipital and sphenopetrosal synchondrosis may be assumed to have an effect on the elongation and lowering of the posterior fossa, and also to influence the growth in width. The lowering of the occiput usually is not accompanied by a marked change in the cranial base form (only 0.7 degree ± 0.13 degree) as expressed by the angle nasion-sella-basion. This parallel lowering of foramen magnum produces only a slight increment in the foramen angle (1.2 degree) so that the balance of the head on an average does not change appreciably with age. However, there appears to be some racial difference in this respect.[2]

The changes in the shape of the cranial base do not appear, in any appreciable degree, to be the result of a raising or lowering of the sella itself during the growth period, although movement of this kind of the sphenoidale bone appears quite feasible during earlier growth periods.

The development is also accompanied by a more or less pronounced enlargement of the sella contour and a raising of the tuberculum sellae on an average by 1.2 mm., in relation to the n-s line, that is, the center of the sella.

A comparison of the x-ray films of 12- and 20-year-old individuals seems to indicate less displacement of the head and face outlines with age, if the center of the sellae is taken as origin, than is the case if they are compared with tuberculum sellae as origin. It would appear, therefore, that tuberculum sellae and dorsum sellae increase in size with age by appositional growth, simultaneously with the increment in the area of the sellae. This means, in effect, that the reference line n-s yields less displacement with age than a corresponding line drawn through nasion and tuberculum sellae.

The radius of the brain case, as measured from the center of the sellae to frontale, shows an average increase of 1.5 mm. and the radius to bregma an

average increase of 1.3 mm., which indicates that the anterior cranial fossa also continues to increase somewhat in size beyond the age of 12. This is also borne out by the fact that the height of the frontal bone, from nasion to bregma, increases by a greater amount than can be accounted for by apposition at the glabella (Fig. 4), which results in a posterior displacement of bregma. This displacement, however, does express itself differently in different individuals, and in certain cases the previously mentioned radii are found actually to diminish in connection with the rotation of the various parts of the brain case, as will be seen from Table I which gives the standard deviation of these growth changes.

An important question in this connection is whether the accumulation of bone on the outer layer of the frontal bone is accompanied by a displacement of the nasofrontal suture, upward or downward, resulting in a corresponding displacement of the n-s line during the growth of the individual. The effect of this kind of deviation, when added to the variations in the development of the sellae, cannot be disregarded in individual cases. In 90 per cent of the cases examined, only a very small change could be detected in the relative position of the contour of the ethmoid plate (reference point ethmoidale) and the n-s line, while in the remaining cases the growth change amounted to plus or minus 1 mm., with only two exceptions, where the difference was 2 mm. This means in fact that the position of the n-s line is remarkably stable in relation to the deepest median contour of the anterior cranial fossa during this developmental period. The latter contour is found to lie at an average depth of 2.2 ± 0.15 mm. below the n-s line, and its variation from that position, expressed as a standard deviation, is 2.4 mm. As this deviation is considerable and the adolescent growth variation in this case is negligible, it can be explained only by variation in growth during fetal life and childhood.

Summary.—The average growth increase in the cranial base between the ages of 12 and 20 is illustrated by the diagram in Fig. 4, which is based on the values given in Table I. Summing up these growth changes, we find that the cranial base is elongated ventrally, due to a frontal apposition at the glabella region, but without any appreciable increase in the length of the anterior cranial fossa. There is a dorsal elongation of the cranial base due to an increment in the length of the clivus, which is accompanied by a dorsal displacement caused by a sutural growth of the lateral portions of the cranial base and brain case, forming the two median cranial fossae and the posterior one, together with a simultaneous lowering of these regions. In effect, this means that the temporal bone, and hence the socket for the jaw joint and the mandible, suffer a rearward and downward displacement. The over-all flattening of the cranial base is insignificant and the lowering of foramen magnum is virtually parallel.

DEVELOPMENT IN A CASE OF ACHONDROPLASIA

The differential effect of the growth mechanism between the medial and lateral regions of the cranial base in a dorsal direction may be illustrated by a case of an achondroplastic dwarf, whose development was followed during

the same period as for the normal subjects, that is, between the ages of 12 and 20 years (Figs. 5 and 6).

In this case the growth in the spheno-occipital synchondrosis had completely ceased during the growth period in question, with the result that the clivus had not increased in length. The growth of the lateral regions of the

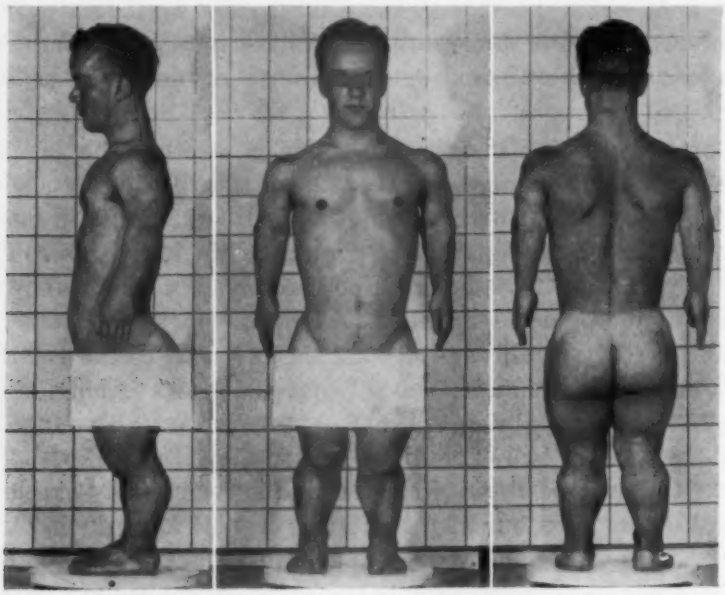

Fig. 5.—An achondroplastic dwarf, 20 years of age.

cranial base have remained active, however, and the temporal bone, and hence the socket of the jaw joint, has suffered a downward and backward displacement due to sutural growth. The most notable feature of this case is the position of the mandibular condyles and the articular tubercle on the one hand and

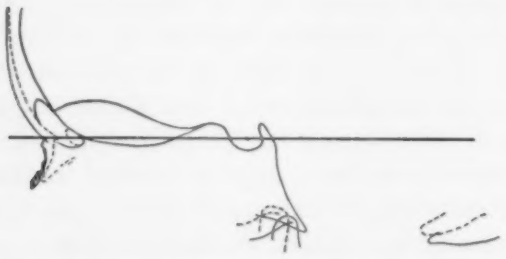

Fig. 6.—The growth pattern of the cranial base from 12 to 20 years in a case of achondroplasia, shown in Fig. 5.

the contour of the clivus at adult age on the other (Fig. 6). The length of the cranial base from nasion to the condylar head at adult age was only 1 standard deviation less than the average. The angle formed by sella-nasion-basion is 2 standard deviations less than the average value; clivus' length and the overall length of the cranial base, however, are 4 standard deviations less.

This case, therefore, serves clearly to illustrate the concepts of the differential development of the various parts of the cranial base. Normal growth and development of the spheno-occipital synchondrosis is essential for a harmonious development of the cranial base, whereas its influence on the development of the cranial base as a whole in my opinion is greatly overrated.

INDIVIDUAL GROWTH VARIATIONS

The general growth pattern described in the preceding is particularly useful when comparing the development tendencies of different populations. However, comparing average values based on figures obtained from different age groups will not provide any information about the dynamic development, which can be ascertained only by analyzing individual development, that is, the growth pattern of the individual.[3, 15, 27]

Form.—The cranial base has been considered to remain constant in shape from the age of about 10 or 12 years and onward. As already pointed out, however, individual age changes in the shape of the cranial base also take place during adolescence up to adult age, and are quite marked. According to Table I, the age changes which take place in the cranial base angle nasion-sella-basion from 12 to 20 years have a standard deviation of no less than 1.9 degrees, with a variation range of 10.5 degrees. In other words, the cranial base angle tends to widen in some cases and in others it closes (Fig. 3, *a* and *b*).

The individual development in form of the cranial base from 12 to 20 years for the whole sample studied is illustrated by the regression diagram in Fig. 7. The regression coefficient $b_{20/12}$ is 0.98 degree, which value does not significantly differ from 1.0 degree. This means that the age changes are the same, irrespective of the shape of the cranial base at 12 years. The individual variation in development within the limits plus or minus 2 standard deviations around the regression line is denoted by the dotted lines in the diagram.

Age changes in cranial base form may be expected to take place as long as the growth process of the head and face continues, as discussed in the previous section of this article.

The range of this age change constitutes 45 per cent of the range of variation at the age of 12 and is given by the quotient s_D/s_{12} in Table I, expressed in per cent. Expressed by this quotient, the age changes in the cranial base form are proportional to those calculated within the facial structure.

Size.—It will be seen from Table I that the individual range of the variation in linear increment with age in cranial base and brain case dimensions is proportional to the range of variation in size at the 12 years of age level, but to a varying magnitude for different groups of determination. The quotient s_D/s_{12} is used as a handy expression for this relation. The quotient is smallest for the radii within the brain case, measured from sella to frontale and to bregma, as might be expected due to the early development of the brain, the values being 32 per cent and 36 per cent, respectively. Within the cranial base

the most marked individual variation in growth is in the length of the clivus (69 per cent), while that of the measurement sella-nasion amounts to 50 per cent (Table I).

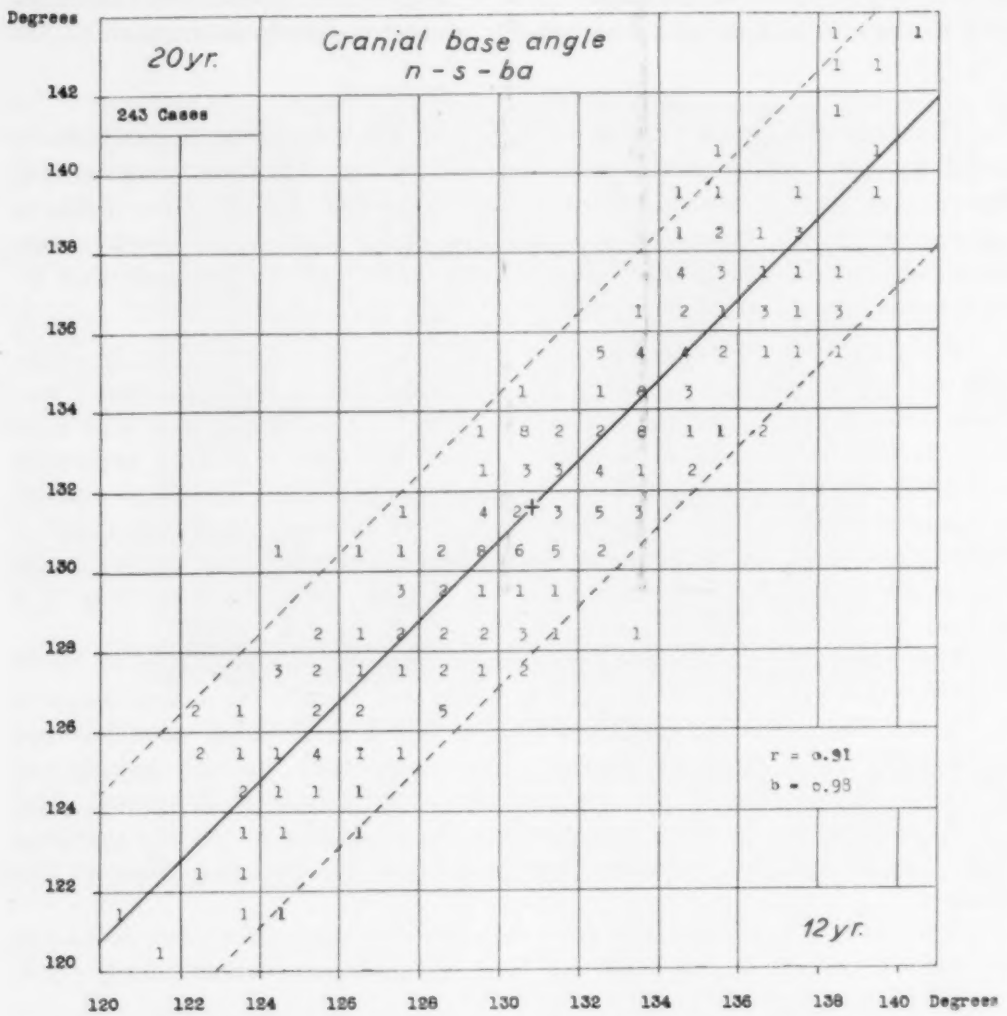

Fig. 7.—Distribution of the cranial base angle, nasion-sella-basion, at 12 and at 20 years of age in the same individuals. The dashed lines indicate the dispersion of the age changes around the regression line within the limits two times the standard deviation ($s_{y/x} = s_y.\sqrt{1-r^2}$).

The thickness of the frontal bone at the glabella is, on an average, 10 mm. at 12 years and 15 mm. at 20 years, with a standard deviation of 2.2 mm. and 2.8 mm., respectively. The gain in thickness with adolescence is considerably greater in cases where the thickness exceeds than where it is less than average at 12 years. This is borne out by the fact that the regression coefficient, $b_{20/12}$, calculated from the regression of the values at 20 on the values at 12 years, is 1.12 mm., which figure differs significantly from 1.0 mm. This mode of periosteal growth at the glabella region will reflect also the gain in length of the anterior cranial base. The coefficient $b_{20/12}$ for the distance n-s is cal-

culated to be 1.09 mm., which value also differs significantly from 1.0 mm. The adolescent gain in length of the dorsal portion of the cranial base (s-ba, s-ar) or of the total length (n-ba, n-ar) is, on the other hand, independent of the prepubescent size.

Summary.—The analysis of the individual growth changes indicates that changes in the shape of the cranial base with age are a normal occurrence also during adolescence and that in individual cases such changes may assume important proportions and that they may differ individually as regards magnitude and direction. The shape of the skull and facial structure is influenced by a multitude of variation factors, all of them correlated in greater or lesser degree. The growth pattern of the individual is determined by the manner in which these growth variations are correlated. In a following section the coordination in shape of the cranial base and that of the brain case and the facial structure will be discussed. As the relation between age changes in form and size is of great interest, this relation will be analyzed in more detail and on a broader basis in the following section.

GROWTH AND FORM

Individual Variation.—A numerical value of the individual growth variation in the sample studied is to be found in the standard deviations of the calculated age changes (s_D). It will be seen from Table I that these values are appreciable for all the features studied in the cranial base and the brain case. This applies in general to both angular and linear measurements, although the values do vary for different regions.

For the sake of completeness, the same values relating to the facial structure have also been included in the following discussion, and also determinations of the bite development (Figs. 8, 9, and 10). For the face and bite the variations of the different determinations are given in the diagrams only. In the case of the cranial base angles, the foramen angle, and the various facial angles, the value of the quotient s_D/s_{12} lies between 0.45 and 0.65. The range of the variation in form with growth thus roughly amounts to 55 per cent (45 to 65 per cent) of the range of variation in form at 12 years, as far as the cranial base and the face are concerned. The magnitude of the variation in form (s_{12}), in other words, is definitely related to the magnitude of the individual age changes in form (s_D), as illustrated in Fig. 8, *a* (heavy line). If the variation of a certain feature is known, it is therefore possible to assess the range of the individual growth variation with a fair degree of accuracy, as indicated by the regression calculations. The figures related to the bite development (dotted line) will be discussed later.

The relationship between variations in size and variations in linear growth increment within the cranial base and the facial structure is illustrated in a diagram in Fig. 8, *b*. The quotient s_D/s_{12} for linear determinations within the cranial base and face is, on an average, 0.65 (0.50 to 0.83). This denotes that the range of the increment in size with age during adolescence is roughly 65 per cent of the range of variation in size at 12 years of age, varying from 50 to 83 per cent. It will be noted from the regression calculations in Fig. 8, *b*

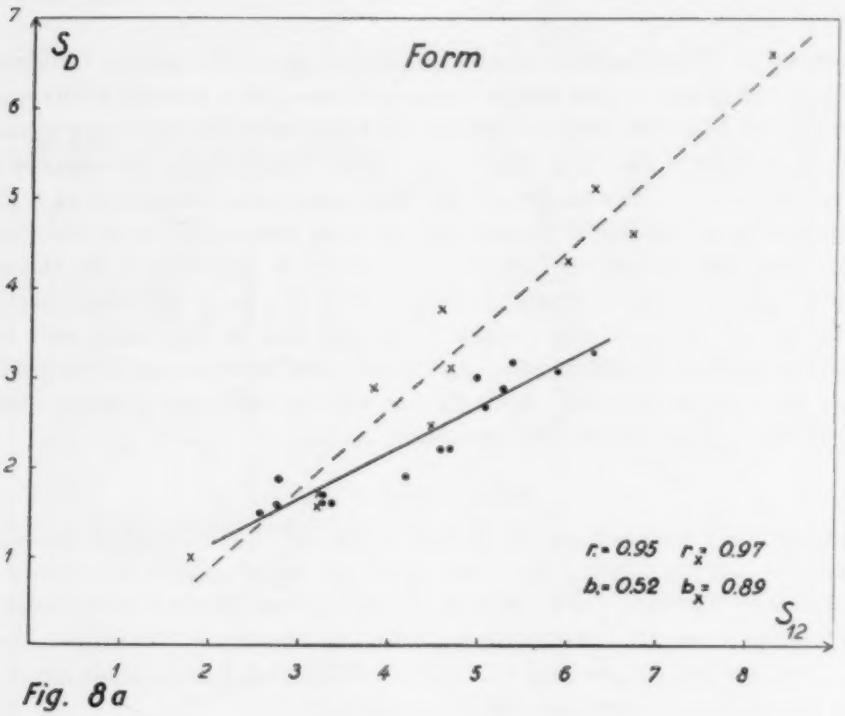

Fig. 8a

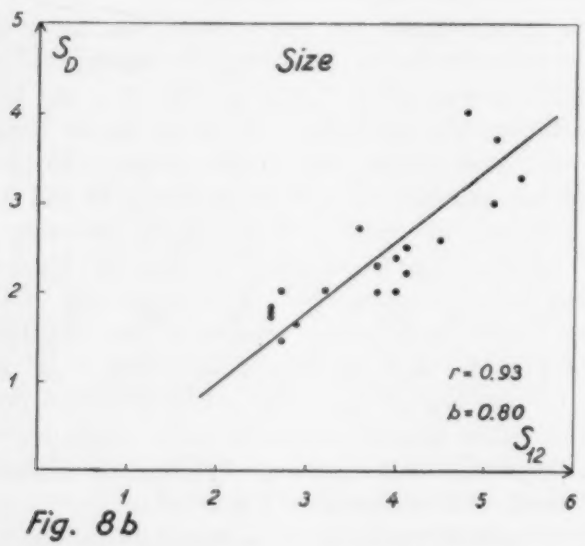

Fig. 8b

Fig. 8.—The relationship between the standard deviation for different determinations at the 12 years of age level (s_{12}) and the standard deviations for the individual age changes between 12 and 20 years for the same determinations (s_D): (*a*) angular and (*b*) linear determinations. Determinations within the face and cranial base are denoted by dots (.); within the bite by crosses (x).

that the relation between variation in linear increment (s_D) and variation in size (s_{12}) is as regular as was the case for the form, as discussed previously.

Average Change in Form and Size.—If the range of the age changes in form during growth tends more in one direction than in the other the average form will change somewhat with age. For instance, the jaw angle in the present material is found to decrease on an average by 3.4 degrees between the ages of 12 and 20. The range of the individual age changes, however, was found to vary between +5 and −12 degrees, with a calculated standard deviation of 3.1 degrees (Fig. 14). In one case there was found to be an extreme opening of the jaw angle, amounting to 11 degrees.

If, on the other hand, the growth changes are uniform in magnitude in both directions, the mean value will remain unaffected with age. It does not follow that the individual variation in form with age is less for that reason.

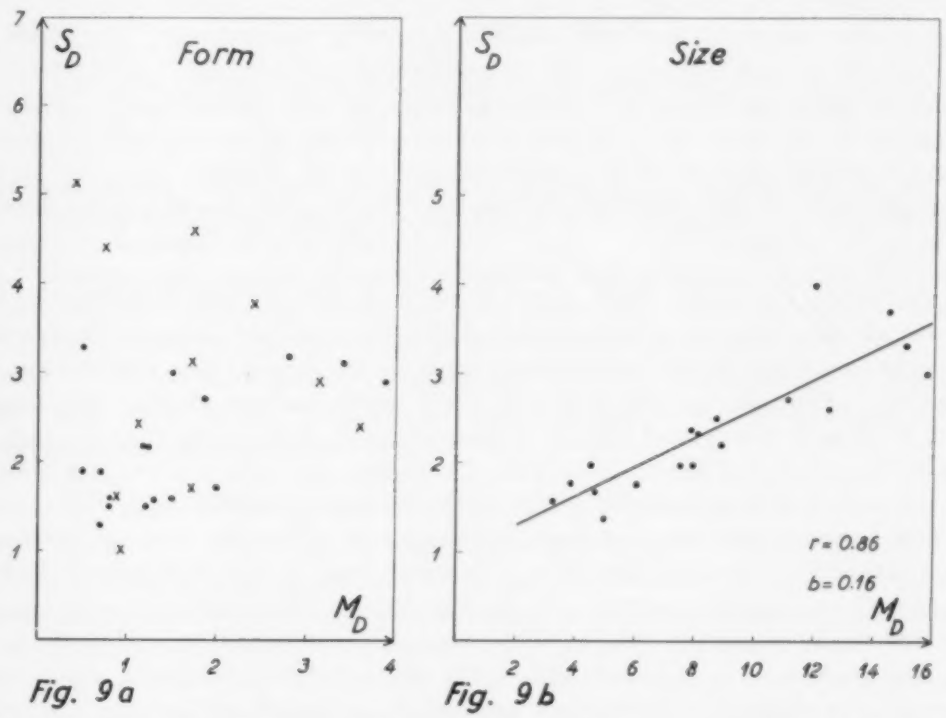

Fig. 9 a Fig. 9 b

Fig. 9.—Relationship between the displacement of the mean values from 12 to 20 years (M_D) and the standard deviations for the individual age changes (s_D): (*a*) angular and (*b*) linear determinations. Determinations within the face and cranial base are denoted by dots (.); within the bite by crosses (x).

The independence of the magnitude of the individual age changes in form (s_D) and the change in average form with age (M_D) is illustrated in the diagram on Fig. 9, *a*.

The range of the linear increment with age (s_D), on the other hand, is, as expected, directly proportional to the average increment in size (M_D) as shown in Fig. 9, b.

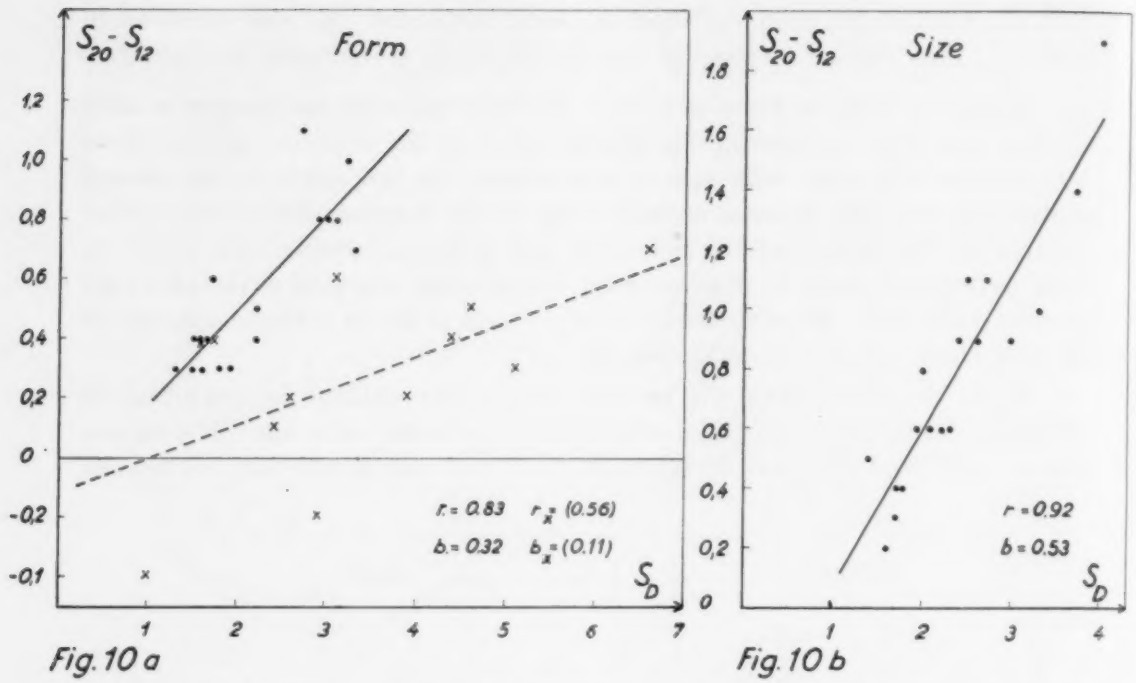

Fig. 10.—Relationship between the standard deviations for individual age changes (s_D) and the increasing variation from 12 to 20 years ($s_{20} - s_{12}$). *a*, Form (angles); *b*, size (linear determinations). Determinations within the face and cranial base are denoted by dots (.); within the bite by crosses (x).

Increased Variation With Age.—Because of the individual difference in growth change, as regards both form and size, the standard deviation increases somewhat with age for all measurements within the cranial base and the facial structure. Thus, the values of s_{20} are in all determinations greater than those for s_{12}, for both linear and angular measurements. This means that the variation in form and size increases somewhat with age and that this increase is correlated with the magnitude or range of the individual age changes. The connection between the range of the age changes in form (s_D) and the increase in variation in form with age (s_{20}-s_{12}) is illustrated by the regression calculation based on angular measurement in Fig. 10, *a*. The same relation is found also for linear measurements, as illustrated diagrammatically in Fig. 10, *b*.

The increment in the variability with age in form as well as in size is not very pronounced, but nevertheless significant, as sample differences are here excluded.

Modification in Form With Age.—Age changes in the bite are, as referred to previously, of a totally different order of magnitude, as regards both form and size (angular measurements to the occlusion plane, of the inclination of the incisors, etc., and the dimensions of dental and alveolar arches). The range of the age changes in the bite form in relation to the variation at the age of 12 for different determinations is found to vary between 55 and 85 per cent. The regression diagram in Fig. 8, *a* (dotted line) illustrates clearly that the range of the age changes that occur in the bite form is out of proportion to

those in the facial structure as a whole, and indicates that changes in the bite with age lie outside the regression for age changes in the facial structure and the cranial base. It serves clearly to indicate the fact that the development of the dental and the alveolar arches not only reflects the general growth tendency of the case in question, but that this development is also to be interpreted as the result of modifications or secondary changes in the shape. Modifications of this kind, both dysplastic and compensatory, occur in all dimensions of the bite and their effect is to increase considerably both the variation in form and the range of its age changes. This may explain the tendency toward positive excess in the distribution of some bite determinations. It follows, therefore, that variation in bite or dental arch form is not only a direct consequence of variation in growth and therefore cannot be analyzed as such, as has often been done.

It already has been pointed out in recent publications that in the case of certain properties of the bite the previously mentioned compensatory changes are greater than the dysplastic ones during the adolescent period in question.[4, 5] As a result of this, a certain skewness becomes evident in the distributions. The increased variation in bite form with age is, for the same reason, proportionally smaller than for facial determination and in the case of certain properties the variation is even found to diminish, as illustrated in Fig. 10, *a* (for example, for the sagittal relation of the alveolar arches, expressed by the angle prosthion-nasion-infradentale). This can be explained as an effect of compensatory modification.

These notes on the development of the bite have been included because they serve to illustrate the influence of functional forces, especially those of the soft tissues, on the development of the alveolar and dental arches.[17] The extent to which such factors influence the normal development of the head and face as a whole is not easy to determine, although it is appreciable in certain cases of dysplastic facial growth.

DEFLECTIONAL CHANGES IN CRANIAL BASE FORM

The growth mechanism of the cranial base has been examined in the present article with special reference to deflectional changes, as this is a question which, in addition to its general interest, is of prime importance in understanding the occlusal age changes that take place in the bite.

Fig. 3 illustrates the growth pattern of the cranial base in those cases which show the greatest increase in the cranial base angle (5 degrees) and the greatest decrease in the same angle (−5.5 degrees). In both cases the contours of the anterior cranial fossa on the x-ray films are found to be coincident at the ages of 12 and 20, whereas the clivus in the first case is found to have swung backward and in the second case forward. The increased forward inclination of the clivus (Fig. 3, *b*) is also accompanied by displacement of the temporal bone and hence of the glenoid fossa in a ventral direction, which in the diagram is marked by the points articulare and by the contour of the articular tubercle. There also has been a concurrent lowering of foramen magnum, due to a lowering of the occipital bone which has effected the balance

of the head on the spinal column. Fig. 3, *a* illustrates the opposite sequence of events, in which the clivus has been deflected rearward, accompanied by a rearward and upward displacement of foramen magnum and of the glenoid fossa.

Relation to Brain Case.—The cases mentioned previously represent the extreme variants in the material. In order to obtain a more generally valid picture of the deflection of the cranial base and the manner in which it varies with the development of the brain case, the age changes in the cranial base angle nasion-sella-basion have been correlated in Table II with the age changes for

TABLE II. RELATIONSHIP BETWEEN CRANIAL BASE DEFLECTION AND HEAD FORM

VARIABLES, CORRELATED WITH THE NASION-SELLA-BASION ANGLE	AT 20 YEARS AGE LEVEL r_{20}	AGE CHANGES BETWEEN 12 AND 20 YEARS r_D
Cranial base angle:		
n-s-ar	0.89	0.86
Forehead angle:		
f-n-s	0.26	0.28
Foramen angle:		
(head balance axis to n-s line)	0.38	0.22
Cranial base dimensions:		
n-s	(–0.09)	(–0.12)
s-ba	–0.25	(–0.10)
n-ba	0.22	0.27
s-ar	–0.25	(–0.13)
n-ar	0.22	0.23
Brain case dimensions:		
f-s	(0.08)	(0.01)
br-s	0.19	(0.01)
l-s	0.21	
br-ba	–0.19	–0.20
n-br	(–0.08)	(–0.12)
n-op	(0.0)	
br-l	(–0.10)	

The deflection of the cranial base, expressed by the angle nasion-sella-basion, is in the first column correlated with the head form at the 20 years of age level (r_{20}). The second column gives the correlation between the age changes in the cranial base angle and the age changes for the different head determinations between 12 and 20 years (r_D).

Insignificant values ($P>0.01$) are in brackets.

each of the determinations which here have been selected as expressions of the development of the cranial base and the brain case (r_D). The appropriate correlations between the values of the cranial base angle nasion-sella-basion at the age of 20 and the other determinations made for the same age are also given in the same table (r_{20}). It should be noted that the values for r_D and r_{20} agree remarkably well and it may be concluded from this that the correlation between values representing a certain stage of development is also an expression of an interdependence in development during growth. It should be noted from Table IV that values of r_D and r_{20} for different variables within the facial structure exhibit comparable agreement. Coordinated variation in shape is an expression of the coordinated variation in growth. A more thorough knowledge of this relationship would be particularly valuable for the purpose of analyzing the craniums of extinct populations in order to get an estimate of the individual variation in development. It is also appropriate to

mention here that the functional modifications in form already referred to will be found to complicate the correlation analysis of the development of the bite.[5]

The diagram in Fig. 11 has been specially constructed in order to illustrate the way in which variations in the shape of the cranial base are tied up with the development of the brain case, in this case at the 20 years of age level. In this diagram the general shape of the cranial base and the brain case for the twenty-three cases showing the greatest flattening of the cranial base, expressed by the angle nasion-sella-basion, is compared with the average shape of the twenty-three cases in which the cranial base shows the greatest degree

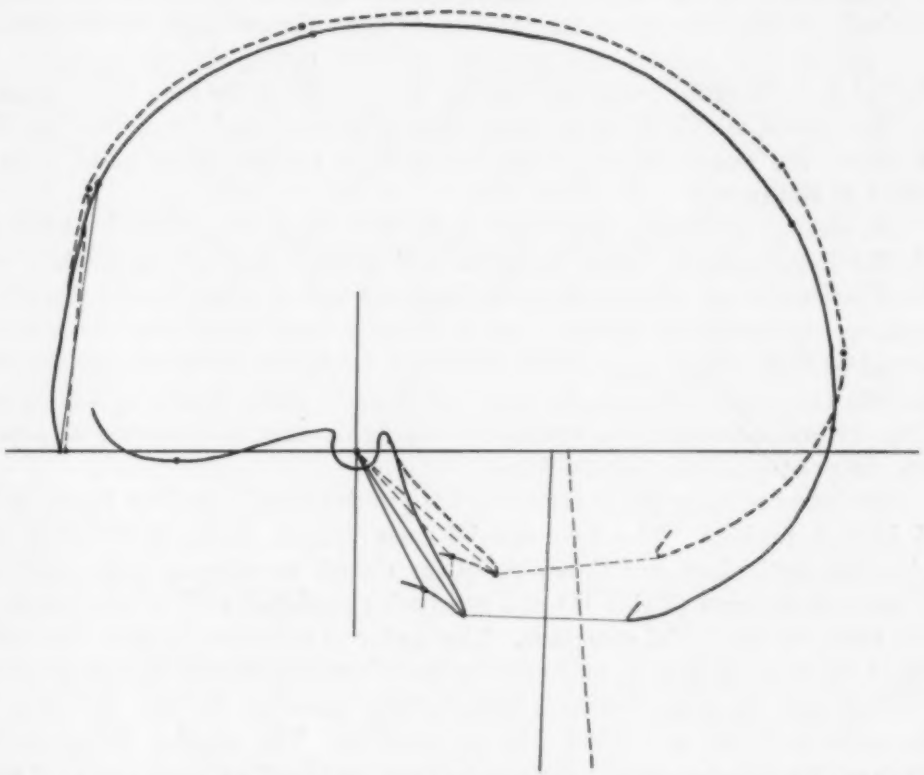

Fig. 11.—The covariation between cranial base deflection and brain case rotation. The drawings are constructed from mean value calculations at the 20 years of age level, from cases with pronounced deflection compared with cases where the cranial base is flattened, each group comprising twenty-four cases (10 per cent of the sample).

of bending. Each of these groups represents 10 per cent of the material collected. The significance of this interdependence in development of cranial base and brain case has been further determined by correlation calculations, based on the entire material (Table II). Fig. 11 illustrates the tendency of this interdependence and, according to Table II, it is of the same order for the 20-year stage as for the growth changes. Consequently, the diagram is also indicative of the interaction during growth.

It will be seen from Fig. 11 that the shape of the brain case varies considerably in relation to the shape of the cranial base. A flattening of the

cranial base is usually accompanied by reduced height of the brain case, as measured from basion to bregma. On the other hand, the radius of the brain case, measured from sella to bregma, is greater, whereas the radius from sella to basion is greatly reduced. The posterior and median cranial fossae are therefore raised in relation to the anterior one. It should be noted that the distance measured from the reference point ethmoidale to the n-s line does not vary in relation to the angular deflection of the cranial base ($r_{20} = 0.0$). Rotation of the brain case, therefore, does not appear to cause any raising or lowering of the anterior cranial fossa. This rotation of the bones of the brain case results in a rearward and upward displacement of the foramen magnum and causes the foramen angle to widen. As the natural balance of the head on the spinal column depends on the location of the foramen magnum, a flattening of the cranial base usually will have the effect of tilting the face upward. In a similar way, Negroid races, such as the Bantus, carry the face tilted up more than Europeans, which gives the impression of greater facial prognathism than is actually the case.[2] The alveolar prognathy, on the other hand, is more marked in Negroes.

The change in the shape of the cranial base is more intimately correlated with the development of the posterior and median cranial fossae than with that of the anterior. The radii of the anterior cranial fossa (n-s, s-f, s-br) do not show any statistical evidence of significant correlation with the shape of the cranial base. The angle of the forehead, however, shows positive correlation with the cranial base angle ($r_{20} = 0.26$, $r_D = 0.28$) which, as will be seen in Fig. 11, indicates that the rotation of the brain case to some degree also reflects the position of the frontal bone.

The interaction in the rotation of the cranial base is evident in its medial and lateral regions. The two cranial base angles, nasion-sella-basion and nasion-sella-articulare, are thus closely correlated, as regards both magnitude and growth changes (Table II) and are both associated with a rotation of the brain case and the facial structure. The center of this rotation is in the medial part of the cranial base to be found in the clivus region, the chondral growth of which may be regarded as a structurally essential feature, allowing the synchondrosis to act as a joint (Fig. 3, *a* and *b*). The rotation due to sutural growth of the side elements of the cranial base, on the other hand, does not occur around any fixed center, as it is the result of a mutual displacement of the individual parts concerned. Its effect is a downward and backward movement of the temporal bone in relation to the frontal bone.

Direct anthropologic measurements of the head and face are available only at the 20 years of age level. It will be seen from Table III that there is no correlation between the cranial base angle, measured from the x-ray plates, and the direct measurement of the length or breadth of the head, width of the cranial base, or width of the facial structure. On the assumption that interdependence in the development of shape signifies interdependence in growth, it therefore may be concluded that growth changes which take the form of cranial base deflection during the period of adolescence are not related with variations in development in width of the cranial base, in every case not to any marked degree.

TABLE III. DIRECT DETERMINATIONS AT THE 20 YEARS OF AGE LEVEL

VARIABLES (MM.)	r_{20}	M_{20}	s_{20}	N
Head:				
Length: glabella-opisthocranion	0.0	195.9	7.0	243
Height: porion-apex, projected in MSP	−0.11	131.3	6.1	241
Width: euryon-euryon	0.0	151.3	5.5	243
Cranial Base:				
Width: biauricular	0.0	133.0	4.7	180
Face:				
Width: bizygomatic	0.0	137.3	4.9	243
bigonial	0.05	107.0	5.6	242
bicondylar	0.0	131.6	6.1	231

Mean (M_{20}) and Standard Deviation (s_{20}). The correlation between the different determinations and the cranial base angle, nasion-sella-basion, is given by the value of r_{20}.
N—Number of cases.

Relation to Head Balances.—The rotation of the cranial base is also interlinked with a rotation of the facial structure. The facial prognathism suffers an average reduction, as regards both the maxilla and the mandible, when the cranial base flattens out.[1] In the present article this interaction is indicated by the correlation calculations given in Table IV and by the example of actual cases in Fig. 12. In retrognathic cases the cranial base is often found to be flattened with the effect that the head is carried with the face tilted upward

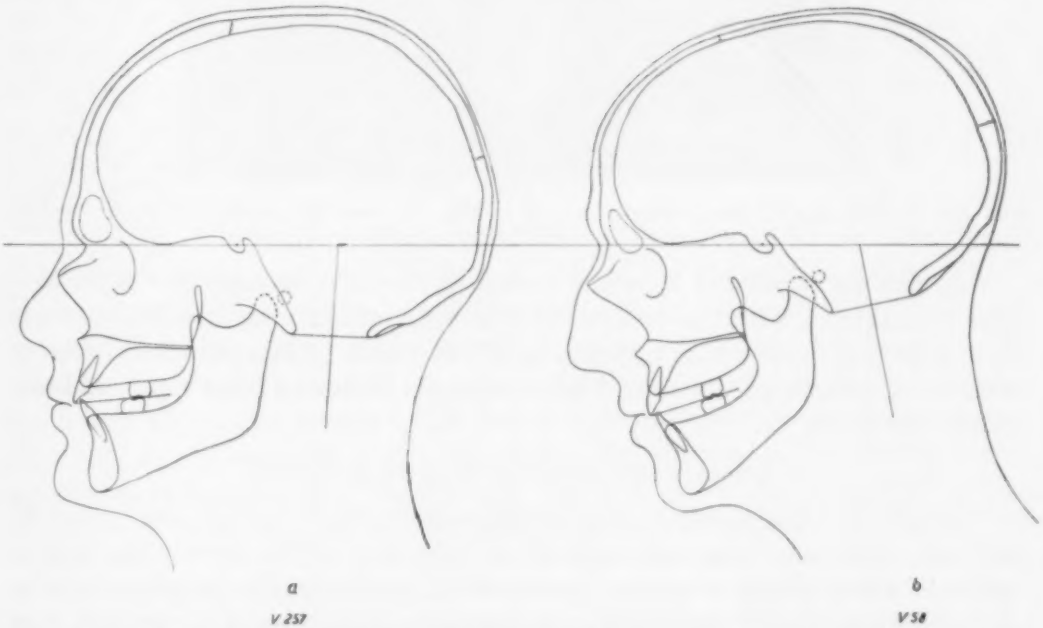

Fig. 12.—X-ray tracings of two 20-year-old individuals representing: (*a*) maximum and (*b*) minimum facial prognathy. The drawings are oriented with the n-s line horizontally.

and with the forehead in a recessive position. The balance of the head, therefore, is largely determined by the location of foramen magnum, as shown in Fig. 13. However, it should be noted that in the case of retrognathy the forehead is not recessive in relation to the cranial base, rather the contrary

TABLE IV. CORRELATIONS BETWEEN CRANIAL BASE FORM AND ANGLES OF FACIAL PROGNATHY

CRANIAL BASE ANGLES	MAXILLARY PROGNATHY (SELLA-NASION-SUBSPINALE)		MANDIBULAR PROGNATHY (SELLA-NASION-POGONION)	
	r_D	r_{20}	r_D	r_{20}
n-s-ba	−0.37	−0.35	−0.33	−0.37
n-s-ar	−0.34	−0.37	−0.31	−0.36

r_D—Between-age changes; r_{20} = at the 20 years of age level.

(Table I). Retrognathy and bulging forehead are two properties that are associated with flattening of the cranial base, although they do not appear to be mutually closely coordinated. The angle of the forehead and the angle of maxillary prognathism, sella-nasion-subspinale, are negative but not significantly correlated ($r_{20} = -0.14$, $r_D = 0.04$).

Fig. 13.—Photographs of the same persons as in Fig. 12, with the heads in free or natural balance.

It may be concluded from the preceding that the rotation of the cranial base is associated with the rotation of both the brain case and the facial structure, a development which appears to be the result of interaction between a number of growth processes and which appears to have a wide range of individual variation.

ASSOCIATION WITH THE FACE AS A WHOLE

Mandible.—The shape of the cranial base is related to the protrusion of both the upper and lower jaws, which is indicated by the correlation figures given in Table IV, as mentioned previously. As far as the mandible is concerned, this is readily evident, as any change in the shape of the cranial base will have the effect of displacing the glenoid fossa in one direction or another in relation to the frontal part of the cranial base, and this movement will directly affect the degree of protrusion of the mandible (Fig. 3). The marked change in the shape of the cranial base that occurs during the fetal stage is quite evidently related to the change in mandibular protrusion, but this relationship has not yet been analyzed in detail.

The total protrusion of the mandible in the profile is dependent on its growth increment in length at the condyle[24, 26] and its direction, as well as on its bodily displacement,[1, 3] due to sutural growth of the cranial base.

The growth direction at the condyles will influence the general shape of the mandible (Fig. 14). An upward direction will increase the vertical height (Fig. 14, *a*). A backward direction will increase the sagittal length (Fig. 14, *b*). The changes which take place in the gonial angle with age will depend on the amount of condylar growth, as well as on its growth direction, in relation to the amount of appositional growth at the gonial angle. The gonial angle is thus more varying in shape with age than any other of the facial structures analyzed in this sample.

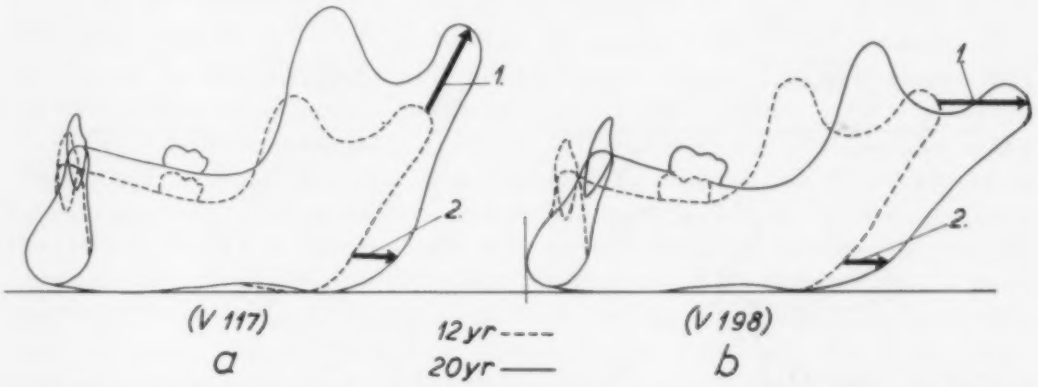

Fig. 14.—Individual variation in mandibular growth pattern; *a* illustrates a case with a vertical direction of the condylar growth (*1*); (*b*) a case with horizontal growth direction (*1*). The amount of growth at the condyle (*1*) and at the gonial angle (*2*) is about the same in both cases. In *a*, the gonial angle is closed with age; in *b*, it is opened. The reduced alveolar prognathy in *b* is a compensatory effect due to soft tissue modeling.

Maxilla.—The relationship between cranial base form and maxillary protrusion is more complicated. In human beings, the premaxillary suture does not appear to influence the longitudinal growth of the maxilla, its body increasing in length mainly in the dorsal direction, toward the vertical plate of the palatine bone, while the maxillary tuberosity is simultaneously incremented by apositional growth. This sutural growth brings about a forward displacement of the maxillary body. The ventral displacement of the maxilla is accompanied by a posterior lowering of the maxillary corpus due to the growth between the palatine bone and the pterygoid processes. The palatine bone therefore appears to play the role of a growing wedge between the maxilla and the sphenoid bone, having for its chief function a dorsal lowering of the maxilla. The rear end of the maxilla is lowered almost vertically, on an average.[1, 9, 30] However, individual variations are to be found in both directions so that in some cases the vertical growth has a forward, and in others a rearward, component.[3] These differences in development are illustrated by the extreme variants in the present sample (Fig. 14, *a* and *b*), from which it will be seen that this development is associated with the changes in the shape of the cranial base.

On x-ray films the rear end of the maxilla is usually marked by a well-defined reference point which may be termed pterygomaxillare (pm) and which can be seen in Fig. 15. The sagittal displacement of the maxilla may be measured from this point parallel with the n-s line. The sagittal displacement with growth, measured in this way, is correlated with the age changes in the cranial base angle nasion-sella-basion ($r_D = -0.33$). The interdependence between the rotation of the clivus and the direction of the growth of the maxilla is to be regarded more as a coordination in growth than as a result of mechanical interaction. The lowering of the maxilla is partly a process of apposition and resorption of the nasal floor[7] and partly connected with the sutural growth of the upper facial structure.[14, 21, 26] Rotation of the lateral

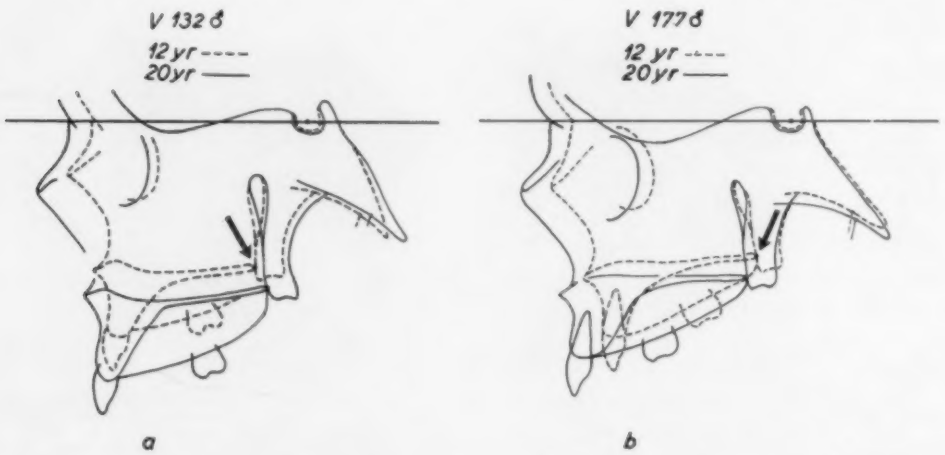

Fig. 15.—Growth pattern from 12 to 20 years in two cases, representing (*a*) downward-backward and (*b*) downward-forward growth direction of the maxillary corpus. (The measuring point pterygomaxillare [pm] is defined as a lateral point, representing the dorsal contour of the maxilla at the nasal floor level, projected in MSP. The point is located on the dorsal contour of the maxilla, upwards forming the anterior border of the pterygopalatine fossa, where it intersects the contour of the hard and soft palate.)

parts of the cranial base, however, may be transmitted through the zygomatic bone of the maxilla and have a direct mechanical influence on the direction of this vertical lowering of the upper facial structure.[1]

The general configuration is thus related to the cranial base development of the face as a whole.[1]

The manner in which the amount and direction of growth of the cranial base, the mandible, and the upper face are accommodated varies in different primates. In the baboon the dorsal elongation of the cranial base is not very marked and the condylar growth of the mandible is directed backward. The protrusion of the mandible, therefore, increases considerably with growth. In the gorilla, on the other hand, the dorsal part of the cranial base increases considerably in length with growth in combination with a marked flattening. This mode of growth retracts the mandible. As the condylar growth is directed upward, the protrusion of the mandible is less marked.

THE N-S LINE AS A REFERENCE LINE

For the purpose of comparing, on a uniform basis, the variations in shape of the facial bone structure and the skull in different individuals and racial groups, a multitude of reference lines have been employed by different authors, these lines being drawn within the facial structure or through the cranial base, or through both.[18] Provided that the object is to establish a reference line which may be readily defined anatomically and which will serve for comparison of the shape of the skull and face, the choice of such a line may be made fairly arbitrarily. This has been the case in classical anthropology and the best known of such reference lines is undoubtedly the Frankfort horizontal which may be readily identified on craniums.

If, on the other hand, the primary object is to choose a reference line which is suitable as a starting point in the study of individual facial development, the problem assumes a different character. A line must be so chosen that it conforms as far as possible to the growth zones of the skull.

Cephalometric x-ray films taken at different stages of development in the individual reveal structural changes in each separate detail. The manner in which the x-ray films are collated to yield a growth pattern embracing all the various regions will depend materially on the choice of reference line. The cranial base seems to be an obvious starting point for the purpose of comparing different stages of development, from both an ontogenetic and a phylogenetic viewpoint. Representing the cranial base as a straight line drawn from nasion to some point in its dorsal region, such as articulare, basion, the Bolton point, porion, or opisthion, is nevertheless too liberal an interpretation of its shape. All the dorsal points just enumerated suffer in upward and rearward or downward and forward displacement with growth in relation to the anterior cranial fossa. This means, in effect, that a reference plane drawn through any of these points does not register those growth changes in the shape of the cranial base, which is of prime importance in interpreting the development of the facial structure in both its sagittal and vertical growth.

A description of the cranial base necessitates dividing it up into dorsal and ventral, as well as medial and lateral, regions. According to my method, the medial region is registered by means of the reference points nasion-sella-basion, whereas the lateral development is expressed in terms of the points nasion-sella-articulare. The point articulare has been selected for purely practical reasons. Some other point, chosen with reference to the jaw joint might serve the purpose better.*

As already mentioned, the possibility of making a comprehensive analysis of the growth pattern as a whole will depend on the stage of development. During the prenatal stage, when all the bones of the skull have a considerable freedom of movement, it is difficult to establish any suitable reference line and during the subsequent postnatal stage the sutural growth of the bone

*In a recent study by Lindegård of head and face form in relation to body build, the lateral cranial base bending was measured from the n-s line to the condylar head. (Lindegård, B.: Variations in Human Body Build, Acta psychiat. et neurol., suppl. 86, 1953.)

forming the anterior cranial fossa may be so pronounced as to cause an appreciable displacement between the frontal, ethmoid, and sphenoid bones. Throughout the period of development with which the present investigation is concerned (that is, between the ages of 12 and 20), the n-s line may be considered as remaining sensibly constant.

The age changes in the facial pattern which emerge from an analysis of this kind become significant only through an appreciation of the regional growth changes and mutual displacement of the bone and it is my hope that this article will serve as a contribution toward the solution of these problems.

A clear understanding of the principles governing the mechanism of growth must be considered a first essential before embarking upon a study of the biologic factors which determine the variations in growth.

SUMMARY

The purpose of this investigation is to analyze the growth mechanism of the cranial base during the period of adolescence in Swedish boys. The material on which the investigation is based consists of two series of standardized lateral head x-ray pictures of 243 individuals, who were first examined at the age of 12 and later subjected to a follow-up study at the age of 20.

The investigation takes the form of a quantitative estimate of the magnitude of the individual growth changes within the cranial base during the growth period in question and the extent and manner in which these growth changes are coordinated with the development of the brain case and the facial development. Other questions that have been analyzed are the relation between variations in form and changes in form during the growth period and the relation between size and linear growth. The results of the investigation have been summarized as follows:

1. The general growth pattern which has been calculated by comparing the mean values for the two stages of development, 12 and 20 years, shows that the cranial base is elongated ventrally by frontal apposition in the glabella region, without any appreciable longitudinal, sutural increment of the anterior cranial fossa. The dorsal elongation of the cranial base, in the medial region due to enchondral growth of the clivus, is accompanied by a dorsal displacement due to sutural growth of the lateral regions of the cranial base and the brain case, forming the median and the posterior cranial fossae and a simultaneous lowering of these regions in relation to the anterior cranial fossa. There is, on an average, an insignificant straightening of the cranial base and there is a virtually parallel lowering of foramen magnum (Fig. 4).

2. The general growth pattern does not give any clue to the dynamic development, which becomes evident only through analysis of the individual growth patterns.

Variations in the individual growth with age have been expressed through the standard deviations for the individual age changes (s_D). The discussion includes the variation in the cranial base and face as a whole.

A. The individual variation in form with age (s_D) is found definitely to be correlated with the range of variation in form (s_{12}). The individual variations of the age changes in form of the cranial base and the facial structure between the ages of 12 and 20 amount roughly to 55 per cent of the variation in form at the age of 12 (Fig. 8, *a*). A similar relation is found to exist between the variation in linear increment (s_D) and the variation in size (s_{12}) (Fig. 8, *b*).

B. The individual age changes in form vary in magnitude irrespective of whether or not the average form for a given feature changes with age (Fig. 9, *a*). On the other hand, the average size increases with age in proportion to the variation in linear growth (Fig. 9, *b*).

C. The variation in form increases somewhat with age and in definite proportion to the individual variations in the growth changes (Fig. 10, *a*). The variation in size is also proportional to the variation in linear increment (Fig. 10, *b*).

D. A coordination in form or size also expresses a coordination of the individual age changes.

E. The relation between shape and its change with age in the bite departs in many ways from the corresponding relation in the facial structure and the cranial base. The reason for this is that the age changes within the bite are due largely to functional modifications that occur with age.

3. The shape of the cranial base may be considered on an average, to remain stable with age. It shows, however, a marked individual variation with age as regards increased or diminished bending in individual cases; that is, it varies in either direction.

A. Rotation of the medial regions of the cranial base has for its center the spheno-occipital synchondrosis. This rotation is coordinated with a rotation due to sutural growth of the lateral regions of the cranial base and the brain case.

B. The shape of the brain case varies greatly in relation to the shape of the cranial base. A flattening of the cranial base usually has, as a result, a low brain case, the total height of which, measured from basion to bregma, is low. The radius of the brain case, measured from sella to bregma, is increased, however, and this is accompanied by a marked reduction in the radius, measured from sella to basion, causing the posterior and median cranial fossae to be raised in relation to the anterior one. Rotation of the cranial base and the brain case does not result, however, in any raising or lowering of the anterior cranial fossa. Foramen magnum is displaced backward and upward and the foramen angle increases, resulting in an upward tilt of the face (Fig. 11). The rotation of the cranial base seems not to be coordinated with the growth in width of the head and facial structure.

4. In coordination with the rotation of the cranial base and the brain case, there is also a rotation of the facial structure.

A. The temporal bone, and hence the glenoid fossa, is displaced downward and forward or backward and upward as a result of the cranial base

rotation and consequently brings about changes in the mandibular position. The direction of growth at the condyle will influence the general shape of the mandible. A more upward direction will increase the vertical height; a backward direction will increase the sagittal length. The size of the gonial angle will depend on the amount of condylar growth as well as on its direction in relation to the amount of appositional growth at the gonial angle (Fig. 14).

B. The body of the maxilla increases in length toward the palatine bone and is lowered as a result of the growth which occurs between the palatine bone and the pterygoid processes. In the individual this lowering may be forward and downward or rearward and downward, a variation in the growth direction of the maxilla which is coordinated with the cranial base rotation and with the sutural growth of the upper facial structure (Fig. 15).

5. During the period of adolescence, the relation between the nasion-sella line and the deepest median contour of the anterior cranial fossa remains noticeably constant, whereas tuberculum sellae and dorsum sellae appear to be raised in relation to the center of the sella. For this reason, the n-s line appears to be particularly suitable as a reference line during the adolescent period in man. Its suitability as a reference line for investigations into earlier growth periods remains to be investigated.

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Editorial

Orthodontics vs. Orthodontia

SPEAKING of orthodontic nomenclature, a feature writer* on the editorial page of the Chicago *Tribune* recently used a new adjective describing orthodontists, that has caused some hubbub. It seems that, heretofore, the adjective has never been used, or even heard of, in orthodontic parlance, from Kingsley down to the present time. The writer describes the specialty as one which uses "gold bands and calleidic skill" to transform even the most homely patients into potential models of the straight-toothed type sought by dentifrice advertisers.

Readers looked to their dictionaries and encyclopedias. The *New Gould Medical Dictionary,* ed. 5, says that the word comes from the Greek *calleidic* and means "making beautiful." That suggests still more important nomenclature matters in orthodontics that require dictionaries, tolerance, and a patient understanding of orthodontic background, heredity, and environment.

The Third Nomenclature Conference "Troublesome Terms, A Workshop on Perennial Problems in the Dental Vocabulary," sponsored by the Bureau of Library and Indexing Service of the American Dental Association, Chicago, Sept. 3 and 4, 1954, has some interesting things to say in regard to many of the terms used in the practice and study of the various branches of dentistry.

Under the heading of "Prognathism" the report says: "The term *prognathism* should not be used without determining restricting and localizing adjectives, as for instance: *total facial* prognathism, *total maxillary* prognathism, *alveolar maxillary* prognathism, *alveolo-dental* prognathism, *total mandibular* prognathism, *total alveolo-dental* prognathism, etc."

On pages 12 and 17 of the report are the following: "The *-ics* ending for the specialties of practice is good usage and in most instances preferable usage. There is no etymological reason why *-logy* should not be used to designate a specialty, although it may be criticized from the point of ease of use. . . . In medicine and surgery the ending has been used to indicate some branches of practice. Where a science or department of study exists, it would be useful to maintain the distinction by using *-logy* only in such cases. Orthodontics and prosthodontics are practices; and sciences of 'orthodontology' and 'prosthodontology' can hardly be said to exist."

Dr. James D. McCoy, orthodontist, who served much on this committee, is quoted as saying that malocclusion used by itself is incomplete, that it should be "malocclusion of the teeth." His reasons: "One term frequently appearing in our literature is *malocclusion.* When used by itself, it is a

*Memi.

fine example of word starvation and could be made to apply to any of the natural openings of the human body whose closing function has been impaired."

There are a number of orthodontic terms that have been confusing practically ever since the creation of the specialty away back, at about the beginning of this century. One of these is the name of the specialty itself. In Angle's third edition, published in 1892, for instance, we find the name of the book *The Regulation of Teeth by the Angle System.* Later editions of this book were called *Orthodontia.* Others then came along with *Orthodontics, Dento-Facial Deformities,* then *malocclusion of the teeth,* and so on and on.

By accepted usage, and as a result of the official sponsoring by the American Dental Association, and the fact that the *New Gould Medical Dictionary* (published in 1949 by the Blakiston Company, Philadelphia) accepted the word *orthodontics,* it seems that this confusion is settled. The AMERICAN JOURNAL OF ORTHODONTICS for years used both terms—*orthodontics* and *orthodontia*—depending upon the authors' choice. This has been quite confusing to editors, writers, and proofreaders, and it is refreshing to know that at last *orthodontics* is officially accepted as the proper noun for describing the subject by the American Dental Association and by medical dictionaries regarded as authoritative. It will be comforting to publishers and editors, particularly, when all authors will call the subject of orthodontics by the same name.

In the past, even graduate schools in orthodontics have been unable to see eye to eye upon the proposition of whether their students are in attendance for the purpose of taking a course in orthodontia or orthodontics. The A.D.A. seems to have officially decided the question once and for all. *Orthodontics* seems to be the proper name.

H. C. P.

In Memoriam

LAWRENCE WILLS BAKER

1876-1954

LAWRENCE W. BAKER of Boston, Massachusetts, died on Dec. 1, 1954. A native of Woodstock, Vermont, he was graduated in dentistry, Class of 1898 from the Harvard School of Dentistry and from the Angle School of Orthodontia in 1911.

A fitting inspiration for his choice of specialty came from his illustrous father, Dr. Henry A. Baker, who in 1892 originated elastic traction in orthodontic procedures and was the first dentist in history to apply intermaxillary elastic stress, which has since been known as the "Baker anchorage."

Among Dr. Lawrence Baker's many varied accomplishments and contributions to education and scientific research were forty-four continuous years of teaching orthodontics at Harvard. He held the following appointments in the Dental School: assistant in orthodontia, 1900 to 1904; instructor in orthodontia, 1904 to 1910; assistant professor of orthodontia, 1910 to 1921; professor of orthodontics, 1921 to 1944; professor emeritus of orthodontics, 1944 to 1954; member of Administrative Board, 1928 to 1944. He was also on the faculty of the Harvard Medical School and a member of the Commission on Dental Research.

Dr. Baker made many substantial contributions to the science and practice of orthodontics. Among his many papers published, both in this country and abroad, are: "Prefunctional and Functional Influences of Bone Growth," 1936; "Orthodontia, Its Place in Dental Education," 1915; "Back to John Hunter," "A Modern Application of Madder Feeding to Study Growth of Living Bone," 1934; "A Preliminary Study of the Influence of the Forces of Occlusion on the Development of the Bones of the Face," 1910; "The Influence of the Formative Dental Organs on the Growth of the Bones of the Face," 1941.

Dr. Baker was past-president of the Harvard Dental Alumni Association, Eastern Association of Graduates of the Angle School of Orthodontia, International Association for Dental Research (Boston Section), and Omicron Kappa Upsilon Fraternity (Harvard Chapter), and permanent president of the Class of 1898, Harvard University Dental School. He was vice-president of the Northeastern Society of Orthodontists in 1948; he was also an honorary member of Harvard Society of Orthodontia, the American Academy of Dental Science, Harvard Odontological Society, and Northeastern Society of Orthodontists.

He was a member of the Guild of Boston Artists, West Roxbury Historical Society, and the First Parish Church, Unitarian, of West Roxbury, Massachusetts.

Surviving are his wife, Mrs. Lila Nichols Baker; three daughters, Mrs. Paul E. Molloy of Exeter, New Hampshire, Mrs. Hollis P. Nichols of Needham, Massachusetts, and Mrs. Richard S. Bowman of Rye, New York, and six grandchildren.

Dr. Baker was a quiet, unassuming, mild-mannered gentleman of the New England school and moved within a large circle of friends in the orthodontic world. He was one of the older orthodontists of Boston and in the country, and he was much respected by all those within and outside his profession who were privileged to know him.

Whereas the orthodontic profession has lost a distinguished practitioner, scientist, and educator who devoted his life to his fellow man, be it

Resolved that our sense of bereavement be spread upon the minutes as a memorial, and be it further

Resolved that a copy of these resolutions be sent to members of his family as an expression of our deep sympathy and heartfelt condolence.

Walter H. Ellis, Chairman
Necrology Committee
Northeastern Society of Orthodontists

EVELYN SNYDER FRITZ

1904-1954

EVELYN SNYDER FRITZ died Dec. 13, 1954, at Palm Springs, California, after a long illness.

Dr. Fritz was born Aug. 15, 1904, at Brant, Michigan, the only child of Elton and Nora Snyder.

She was educated in the Grand Rapids schools and graduated from Marquette University in 1927.

After graduation, she was an associate in orthodontics with the late Dr. Griswald of Chicago. On his death, she practiced orthodontics at Milwaukee for ten years. For reasons of health, Dr. Fritz moved to California in 1944, and practiced in Beverly Hills and Los Angeles.

She was a former member of the Central Section of the American Association of Orthodontists and kept abreast of the times by taking frequent postgraduate courses and attending many orthodontic meetings throughout the country.

Dr. Fritz was not only an excellent orthodontist, but also an accomplished musician, playing piano, organ, and violin. While in high school she was violinist with the Grand Rapids Symphony Orchestra.

Dr. Fritz had travelled extensively in the United States and Europe, and was active in club work. She was a member of the Beverly Hills Business and Professional Women's Club, Eastern Star, White Shrine, Soroptimist, and Zonta Club.

Burial was at Palm Springs, California. She is survived by her husband, Walter Fritz.

Dr. Fritz was held in high esteem by all who knew her and her passing will be a loss to the host of good friends she had among the orthodontists throughout the country.

Department of Orthodontic Abstracts and Reviews

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Abstracts Presented Before the Research Section of the American Association of Orthodontists, Chicago, May 19, 1954

A Serial Cephalometric Study of Facial and Denture Patterns in Children Having Excellent Occlusion Using Angular and Linear Measurements (Read by Title): By James Q. Barnes, University of Washington, Seattle, Wash.

Problem.—To do a serial study of the growth changes in the skeletal and denture patterns of a group of thirty-four children possessing excellent occlusion. Study to cover a three-year growth period.

Materials.—The group was comprised of sixteen boys and eighteen girls. The mean age at the beginning of the study, for the boys was 12 years and 7 months, and for the girls, 12 years and 1 month. At the completion of the study, the mean age for the boys was 15 years and 7 months, and for the girls, 15 years and 3 months.

Method.—Use of cephalometric headfilms as follows: (1) lateral in full occlusion, (2) lateral with the mandible at rest, and (3) lateral with the jaws wide open. Tracings were made of this series of headfilms, which were made on the 12-year-old children, and angular and linear measurements were completed. Then the same procedure was conducted with the 12-year-old group. Frankfort plane was transferred from the first to the second tracing by registering the two tracings on sella turcica and superimposing lines drawn from sella turcica to nasion.

The method of measurement as presented by Downs and Wylie was used in this study to evaluate the findings.

Means and differences between the means were determined for both groups and the student "t" test was applied to determine if the differences found were significant.

Findings.—(1) Boys appear to be growing more rapidly than girls during this age period.

(2) The boys exhibited a significant increase of linear length in both the maxilla and mandible. The girls did not have a significant increase in maxillary length; however, the mandible did increase significantly in length.

(3) The developmental changes for both the boys and girls, which was recorded by means of the Downs analysis, correlate very well with findings upon size increase.

(4) The skeletal pattern of both the boys and girls changed in positional relationship, with the mandible becoming increasingly protrusive and the profile less convex.

(5) The boys developed less protrusive dentures during this age range studied. The decrease in protrusion was due primarily to the maxillary incisors becoming more upright. No change could be found in the denture of the girls.

(6) The girls in this age range have about completed their growth, as well as maturation changes.

(7) The boys of this age range are in an active growth period and are going through maturation changes.

Summary.—The results of this study point out that the girls tend to mature and have their most rapid growth period earlier than boys. The maturation changes of the facial skeleton tend to be characterized by increased protrusion of the mandibular chin point and a lessening of the convexity of the face. The maturation of the denture is associated with a decrease of the protrusion of the anterior teeth.

A Study of Dentofacial Morphology and Temporalis Muscle Activity in Normal 7-Year-Old Children, Employing Cephalometric Radiography and Electromyography (Read by Title): By Edward B. Cook, D.D.S., and George W. Street, D.D.S., University of Toronto, Toronto, Ontario.

The purpose of this study was threefold: (1) to determine the normal range of variation in the dentofacial skeleton; (2) to analyze normal temporalis muscle activity, and (3) to determine if there is a correlation between temporalis muscle activity and variations in the dentofacial complex.

The group selected comprised forty children, 5 to 7 years of age, equally divided as to sex. Subjects were selected on the basis of normal occlusion, good lip posture, good health, and lack of apprehensiveness.

Dental casts, cephalometric radiographs, and electromyographic records were obtained for each subject. Cephalometric radiographs were assessed by a linear and an angular analysis, and these data were evaluated statistically. All linear measurements were made at right angles to occlusal plane. The angles used were formed by the intersection of the following planes: naision to "A" point (Downs), Bolton plane, sella to nasion plane, Bolton point to anterior nasal spine (ANS plane), occlusal plane, and mandibular plane.

A graphic method of summarizing muscle activity portrayed by the electromyograms was devised for assessment and comparison with other data.

The findings were as follows:

1. The mean closure path was found to be 0 from physiologic rest to occlusal contact, the range being –3 mm. to +3 mm.
2. Positive correlations:
   a. Bolton plane—ANS plane angle with Bolton plane—mandibular plane angle to a 5 per cent level of probability.
   b. Bolton plane—facial plane angle with angle SNA; girls to 1 per cent level, boys to 5 per cent level.
   c. ANS plane-occlusal plane angle with ANS plane—mandibular plane angle to 1 per cent level in boys only.
3. Negative correlations in girls: to 5 per cent level.
   a. Bolton plane-occlusal plane angle with Bolton plane—facial plane angle.
   b. Bolton plane-facial plane angle with Bolton plane—mandibular plane angle.
   c. Bolton plane-facial plane angle with Bolton plane—ANS plane angle.

4. Sex differences:

   a. Maxillary length (A to Ptm) significantly greater in boys to 1 per cent level of probability.

   b. Ratio of maxillary to mandibular jaw length shows a trend to be greater in boys (11 per cent level).

   c. Ratio of middle cranial base (glenoid fossa to Ptm) to mandibular length shows a trend to be greater in girls (10 per cent level).

   d. Girls show a relatively greater upper face height (5 per cent level), as indicated by Bolton plane—ANS plane angle.

   e. Boys show a trend to greater lower face height (15 per cent level), as indicated by ANS plane-mandibular plane angle.

5. No sex differences were observed in the activity of the temporalis muscle.

6. Twenty-seven subjects showed uniform activity of all portions of the temporalis muscle in physiologic rest, but only four showed uniform activity in occlusal contact. The hyperactivity observed in the remainder of the subjects could not be related to variations in the facial skeleton. However, dental factors, such as tooth interference and tooth eruption, appear to be related to muscle activity.

An Analysis of Dental Casts of Patients Made Before and After Orthodontic Treatment (Read by Title): By Aldo A. Dona, D.D.S., M.S., University of Washington, Seattle, Wash.

Stability of the resulting occlusion established by orthodontic treatment has long been a problem for the profession. It is with this problem in mind that this report was undertaken on tooth movement during treatment and the stability of treatment result after retention.

Records of twenty-two patients were taken before and after treatment and after retention. Twelve were non-extraction cases, of which ten were Class I and two were Class II. Ten were extraction cases, of which five were Class I and five were Class II. The age of the patients ranged from 10 to 15 years. The average length of treatment was twenty-six months. The average length of retention was one year. Length of time out of retention was two to six years.

The following observation and measurement were recorded: overbite, overjet, intercanine width, intermolar width, arch length, and number of rotations.

The findings of this study may be summarized as follows:

1. All cases used in this study were judged to be clinically successful cases.

2. Intercanine and intermolar widths revealed a strong tendency to return to the original if increased, or remain the same if not violated.

3. Overbite has a tendency to return to the original measurement after retention.

4. Overjet, after retention, tends to return slightly toward the original, but never extreme as it was in the malocclusion state of the denture.

5. Arch length has a tendency to decrease following retention.

6. Rotations have a strong tendency to return toward the original, but never to the extent found in the malocclusion state of the denture.

In conclusion, it may be stated that, in general, orthodontic cases following treatment tend to seek a state of stability or balance and, therefore, the teeth

are still moving following the retention period until they settle into a balanced state. In reaching this state, it appears that the cases studied had been overcorrected.

The fact that all the cases were judged to be clinically successful would suggest that this is probably a sound clinical philosophy.

A Cephalometric Study of Relationships of the Maxillary and Mandibular Central Incisors of Children Having Excellent Occlusion and Class II, Division 1 Malocclusion (Read by Title): By Richard O. Failor, D.D.S., M.S.D., University of Washington, Seattle, Wash.

The purpose of this cephalometric study was to investigate the relative positions of the maxillary and mandibular central incisors of children exhibiting excellent occlusion and Class II, Division 1 malocclusion of the teeth, comparing the Downs method of denture analysis with that recently proposed by Steiner.

An attempt was made to validate the Downs analysis of the denture pattern by testing whether or not that denture pattern analysis can be used to differentiate between different types of occlusion. This study was undertaken to derive mean and range values for Steiner's recently proposed method of evaluating denture pattern. An effort also was made to evaluate which of the methods of analysis, that is, Steiner's or Downs's, is more critical in differentiating between various types of occlusion and thus would be the more useful for clinical use.

Measurements were made from tracings of headfilms taken of 120 individuals, ranging in age from 11 to 13 years. The excellent occlusion group consisted of thirty boys and thirty girls; the Class II, Division 1 malocclusion group was comprised of thirty boys and thirty girls.

An analysis of the findings led to the conclusion that the Downs method of assessing denture relationships is far superior to the method proposed by Steiner for the following reasons:

1. The Downs measurements readily demonstrate differences between the sexes, whereas the Steiner measurements do not.

2. The Downs measurements are more critical in differentiating between persons possessing malocclusion and those with excellent relationship of the teeth.

A Cross-Sectional Study of Vertical Facial Dimensions of Children With Excellent Occlusions (Read by Title): By Raymond W. McNair, D.D.S., M.S.D., Medford, Ore.

Material consisted of fifty boys and fifty-seven girls with an age range of 7 to 14 years. A line perpendicular to Frankfort-horizontal was drawn through the center of sella turcica through the entire length of the face. Second, right angle lines were drawn from this vertical line to all anatomic points measured in the study. All measurements were made from point nasion located on the vertical line, and each measurement was made to the nearest one-half millimeter. A summary of the findings is as follows:

1. The distance from nasion to menton is greater in the boy than in the girl. At age 13 the difference is less than at 8 years of age because of the earlier maturation of the girl.

2. The average overbite for this sample of clinically excellent occlusions was 3.76 mm. for the boy and 3.2 mm. for the girl.

3. In this study the greatest amount of vertical facial growth for the boy was found to occur from 12 to 13 years of age, and for the girl from 11 to 12. (This did not include boys over 13.)

4. Mandibular ramus increased 6.3 mm. in length for the boy from 8 to 13, and 10.9 mm. from 7 to 13 for the girl.

5. The range of mean values for the measurement of nasion to Frankfort-horizontal was 27.3 to 28.9 for the boy, and 26.2 to 27.8 for the girl. The distance from nasion to point sella was 3.3 mm. less at 13 than at 8 years of age for the boy, and 3.0 mm. less for the girl at 13 than at 7 years of age.

A Study of Intelligence Quotient and Manual Dexterity as Related to the Incidence of Sucking Habits in Children (Read by Title): By A. W. Shanks, D.D.S., University of Toronto, Toronto, Ontario.

A group of forty-three white children between the ages of 5½ and 8½ years was studied to determine the relationship between the incidence of sucking habits and intelligence quotient or manual dexterity. This group comprised (A) twenty-five children who previously indulged or presently indulge in any form of sucking habit, excluding the lips or cheeks, and (B) eighteen children with no history of a sucking habit, who served as the controls.

Information as to feeding, the habit type, time of onset, and duration was obtained by questionnaires. Intelligence quotient (I.Q.) scores were obtained by the method of the Stanford Revision of the Binet-Simon Intelligence Tests. These scores were gathered in routine study by the staff of the Institute of Child Study, University of Toronto. A measure of manual dexterity was devised, using three component tests of the Oseretsky General Motor Proficiency Tests.

Findings.—It was found that the incidence of sucking habits was higher among children of lower I.Q. That is, the habit group (A) possessed a significantly lower average I.Q. than the control group at 1 per cent probability level. In the habit group there was no significant I.Q. difference between the children who have discontinued the habit and those who still indulge.

There was no significant difference in manual dexterity between the habit group and the control. Nor was there a significant difference in the habit subgroups between those who had stopped and those who continue the habit.

A slight positive correlation was found between I.Q. and manual dexterity scores obtained for the entire sample of forty-three children.

The over-all data indicated that further work, involving larger samples of some of the subclassifications (for example, habit group [female], frequency of indulgence, etc.) would be worth while, if only to obtain statistically more conclusive results for a number of statistical tendencies observed.

Reproducibility of Radiographic Recordings of Rest Position of the Mandible in Young Adults (Read by Title): By John H. McNutt, B.A., D.D.S., M.S.D., University of Minnesota, Minneapolis, Minn.

This investigation was undertaken to study the reproducibility of mandibular rest position intraindividually, from person to person, and the possible effects from certain introduced variables.

A group of twenty-five young adult men with essentially normal dental occlusions were selected for the study. A series of cephalometric radiographic recordings of the rest position was made for each subject, with later deliberate introduction of certain variables in the form of orientation to the concept of rest position, and fatiguing of involved musculature.

A method of measuring the amount of interocclusal space at the recorded rest position was used. Several analyses of the data thus accumulated were made to study the various interrelationships.

Principal experimental findings in this study were that there was variation in mandibular rest position intraindividually, from person to person and from stage to stage. (Stage designated the degree of orientation to the concept of rest position and/or fatiguing of involved musculature). The smallest intraindividual variation in interocclusal space at the rest position in a single stage was 0.00 mm. (one subject). The largest intraindividual variation in a single stage was 4.25 mm. The smallest intraindividual variation in interocclusal space at the rest position over all stages was 1.50 mm. The largest was 12.00 mm. There was no patterning of the variation in rest position intraindividually or from person to person. There may have been a slight tendency toward an increase in amount of interocclusal space with orientation and fatiguing, and toward a slight decrease in variability of mandibular rest position with intensive orientation and fatiguing, but in neither case was there sufficient evidence to make possible any generalizations.

The conclusions were:

1. There was variation in rest position in the serial radiographic recordings in all twenty-five subjects included in the study. This variation showed no tendency toward patterning or direction.

2. There were large differences in the average amount of interocclusal space from person to person.

3. There were large differences in variability of rest position from person to person.

4. There were significant differences in the average amount of interocclusal space from stage to stage. There seemed to be a tendency toward increase in amount of interocclusal space with orientation to the concept of rest position, and fatiguing of involved musculature. However, there was no definite pattern that could be predicted for the individual subject.

5. While there may have been a very slight tendency toward a decrease in variability of the rest position with orientation to the concept and fatiguing, there was no patterning for individual subjects.

6. There seemed to be no evidence for correlation between mandibular vertical position at the rest position and the position of hyoid corpus.

As a result of this study, the investigator thinks that the rest position of the mandible may be far less reliable than it has been believed to be. Probably a great deal of caution should be exercised in the clinical application of the concept of rest position.

A Lateral Cephalometric Study of the Skeletal Pattern in Cleft Palate Patients From 6 to 13 Years of Age (Read by Title): By Malcolm Yasny, D.D.S., University of Toronto, Toronto, Ontario.

This study deals with the developmental skeletal pattern in cleft palate patients from the viewpoint of (a) the influence these clefts may have on the development of the jaws and dentition and (b) whether the influence of the unilateral clefts differs from that of the bilateral or of the posterior clefts.

Measurements were made on lateral cephalostatic roentgenogram tracings of cleft palate patients. The sample included twenty-two patients with clefts on the left side (mean age, 9.0; range, 6 to 13); nineteen patients with bilateral clefts (mean age, 8.2; range, 6 to 13); and nine patients with clefts on the right side (mean age, 7.1; range, 6 to 11). The sample was not divided as to sex.

Various measurements were made, including many of the same areas as investigated by Gilley (*Northwestern Bull.*, 1947) and Grater (*Am. J. Orthodontics*, 1949).

Only a few measurements were significantly different between the three different types of clefts.

1. The inclination of the upper central incisors to Frankfort plane was much less (that is, they were more lingually tipped) in the bilateral clefts than in the unilateral series.

2. The PTM—ANS (anterior nasal spine) measurements in the bilateral series was greater than in either unilateral (mean of 55.7 mm. to 51.1 mm. in left, and 50.6 mm. in right unilateral clefts).

This indicates that during surgery the premaxilla, lacking bony attachment, is more or less rotated about a horizontal plane. The central incisors are then carried with it so that their incisal edges point more lingually and the ANS comes to lie more anteriorly.

3. The angle sella—nasion—ANS measured 89.5 mm. in bilateral clefts against a mean of 81.8 in unilateral clefts.

4. Nasal height percentage in bilateral clefts measured 43.0 per cent, against 41.6 per cent in unilateral clefts.

5. Maxillary height percentage registered 41.5 per cent in bilateral clefts, against 43.0 per cent in unilateral clefts.

6. The maxillary first molar was found to be more distal in position than in normal mouths (mean 12.2 mm. in bilateral clefts and 13.0 mm. in unilateral clefts).

Since the premaxilla in unoperated bilateral clefts lacks bony attachment, then the downward and forward growth of the nasal septum should be greater, resulting in a more anterior and inferior position for ANS. Points 2 and 3 support the fact that ANS lies more anteriorly, but points 4 and 5 indicate there is no significant change in its position vertically.

Standardized Radiography Applied to Patients With Abnormal Growth and Development Patterns: By Melvin I. Cohen, Harvard School of Dental Medicine and Children's Medical Center, Boston, Mass.

This is a study of cranial structures in patients with muscular dystrophy. The clinical observation has been made that the cranium appears unusual in some of these patients. This observation will be tested by lateral headplates.

News and Notes

American Association of Orthodontists
Entertainment and Recreation in San Francisco

Golfers, if you would like to dig some divots on Tuesday afternoon, May 10, on one of our picturesque courses, where clubs may be rented, communicate immediately with Dr. Arnold Wieser, 450 Sutter St., San Francisco, California.

Monday, May 9 is the date of the Golden Anniversary Luncheon for the fifty-year members and the "Get Acquainted" Dinner for members and ladies.

For Tuesday afternoon, May 10, a chartered bus sightseeing tour of San Francisco for members and ladies has been planned for photographers accompanied by an expert photographer.

Wednesday noon, May 11, the Round Table Luncheon will be held.

Wednesday night, May 11, has been set aside for the president's reception, dinner, floor show, and dance.

For the Ladies:

May 9 and 10. Complimentary Continental Breakfast which has been enjoyed so much in the past.

Monday, May 9. "Get Acquainted" Dinner for members and ladies (as above).

Tuesday morning, May 10. Special conducted tour through world-famous Gump's Oriental Art Shop.

Tuesday, May 10, 1:30 P.M. Chartered bus sightseeing tour (as above).

Wednesday, May 11. Luncheon and fashion show by Joseph Magnin's, smart women's apparel shop.

Wednesday evening, May 11. President's reception, dinner, floor show, and dance (as above).

Pacific Coast Society of Orthodontists

The Northern component meets the second Tuesday of March, June, September, and December.

The Central component meets the second Tuesday of March, June, September, and December.

The Southern component meets the second Friday of March, June, September, and December.

Northern Component

The regular meeting was held in Room B-209, Health Science Bldg., University of Washington, Seattle, on Nov. 1, 1954. Chairman George McCulloch opened the meeting.

Central Component

The annual Christmas party was held on December 15 at The Family, as has been the custom for the past few years.

Southern Component

The meeting was called to order by Chairman Herbert Shannon on Friday afternoon, Dec. 10, 1954, in the Los Feliz Brown Derby. Program Chairman Arthur Everett introduced Lloyd Cottingham who was given the privilege of introducing Harvey Stallard, D.D.S., Ph.D.

His subject, "The Good Mouth," covered all parts associated with the official definition of *mouth*, and articulation of the teeth and temporomandibular joint were given special attention.

No report of formal meetings of other components is recorded at this time.

Retired Orthodontists

Some months ago announcement was made to the editorial staff of the JOURNAL that the editor often receives inquiries as to the whereabouts of retired orthodontists and that the readers desire to have news about them.

Word is received indirect from one of the pioneer orthodontists, Dr. Frank Castro, ex-president of the American Society of Orthodontists, ex-president of the American Dental Association, and former Dean of Western Reserve University. Dr. Castro, formerly of Cleveland, Ohio, is now retired and located in La Jolla, California. He recently submitted to two major operations; however, he is reported to be back on his feet and doing well. Many will rejoice with the news of the recovery of Dr. Castro, one of orthodontics' outstanding figures and a graduate of one of the Angle classes early in this century.

Thomas P. Hinman Mid-Winter Clinic

The forty-third session of the Thomas P. Hinman Mid-Winter Clinic will be held in the Municipal Auditorium in Atlanta, Georgia, March 20 through 23, 1955, under the auspices of the Fifth District Dental Society. Dr. Edwin C. Pound is chairman and Dr. Thad Morrison, Sr., is publicity chairman for the meeting.

Participants who have already confirmed their engagements include: Daniel F. Lynch, President of the American Dental Association, Washington, D. C.; Joseph L. Bernier (Pathology), Washington, D. C.; Ralph W. Ireland (Children's Dentistry), Lincoln, Nebraska; Gordon W. Johnston (Amalgam) Toronto, Canada; Carl R. Oman (Ultrasonic Cavity Preparation), New York, N. Y.; S. Howard Payne (Prosthodontics), Buffalo, New York; and LeRoy W. Peterson (Oral Surgery), St. Louis, Missouri. No field of modern dental science has been overlooked, and every subject will be represented by a well-known authority. All members of the profession in the Southeast are invited.

American Association for Cleft Palate Rehabilitation

The American Association for Cleft Palate Rehabilitation will hold its annual meeting May 13 and 14, 1955, in Boston, Mass.

International Dental Federation

The 43rd Annual Meeting of the International Dental Federation will be held Aug. 14 to 20, 1955, in Copenhagen, Denmark.

For additional information write to: W. Riis Klasen, 1, Alhambravej, Copenhagen V, Denmark.

Notes of Interest

Harold J. Klein, D.D.S., announces the opening of his office in the Peoples Trust Building, 381 Broadway, Westwood, New Jersey, practice limited to orthodontics.

Dr. William A. Murray, 636 Church St., Evanston, Illinois, orthodontics exclusively, announces his association with Glenn E. Jackson, B.A., D.D.S., M.S.D.

Leon Perahia, D.D.S., announces his return from service with the United States Air Force and the opening of his office at 620 Fort Washington Ave., New York City, practice now limited to orthodontics.

OFFICERS OF ORTHODONTIC SOCIETIES

THE AMERICAN JOURNAL OF ORTHODONTICS is the official publication of the American Association of Orthodontists and the following component societies. The editorial board of the AMERICAN JOURNAL OF ORTHODONTICS is composed of a representative of each one of the component societies of the American Association of Orthodontists.

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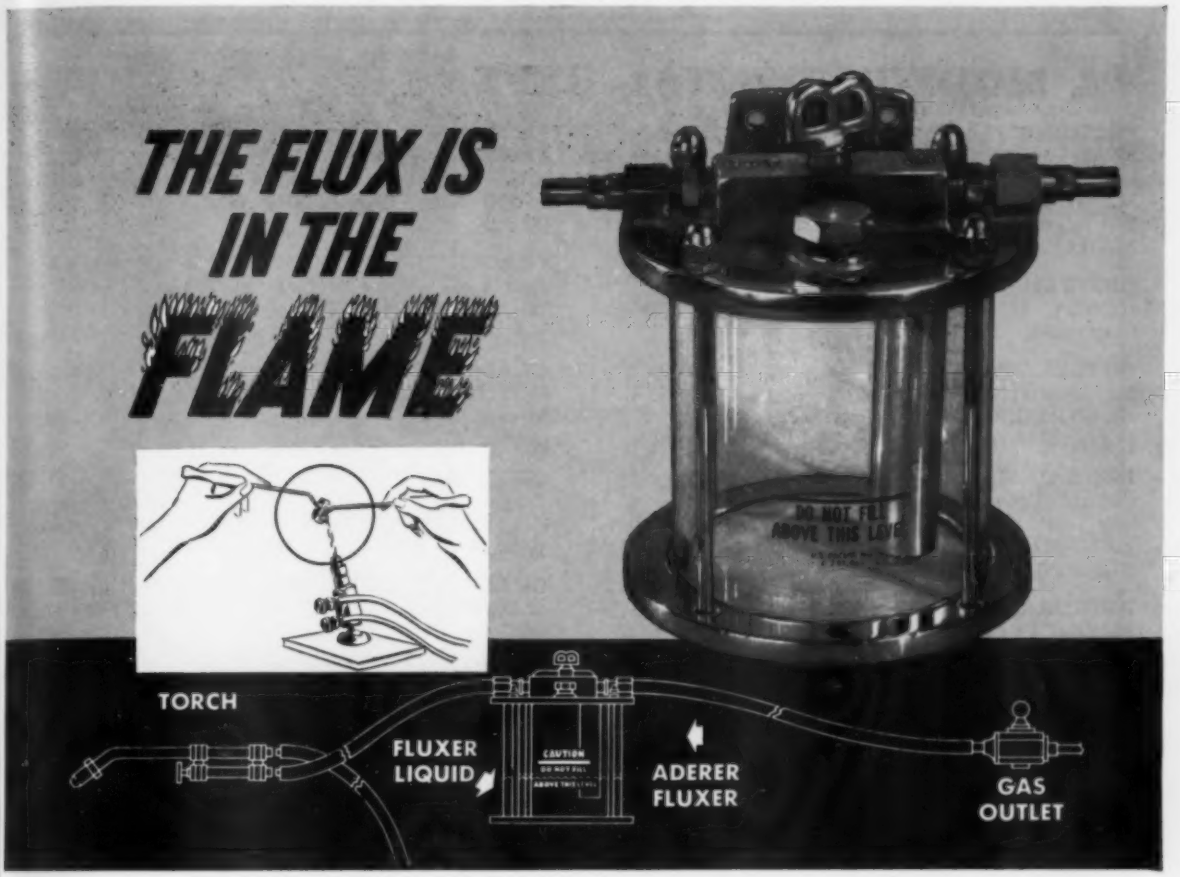

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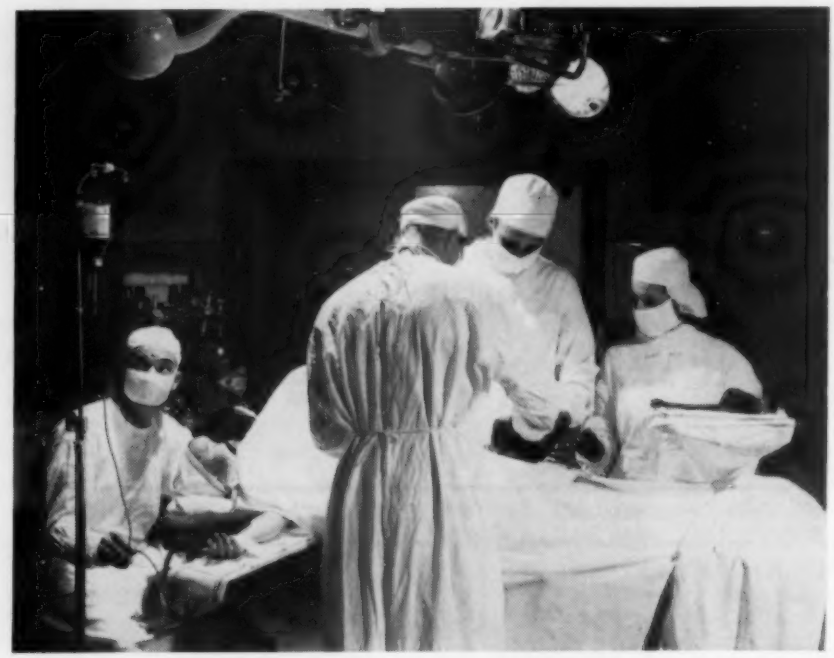

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